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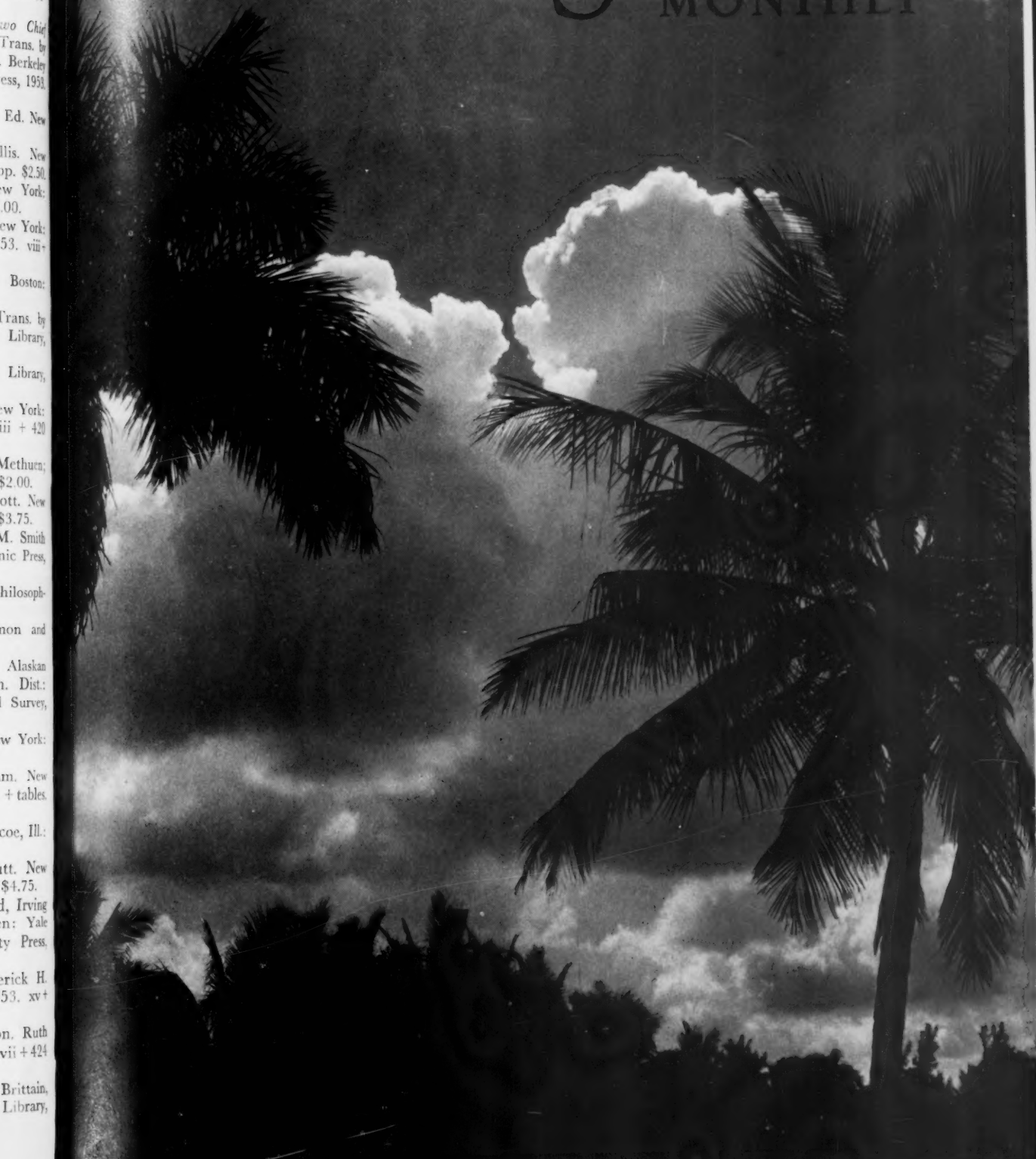
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THE SCIENTIFIC MONTHLY

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Contents

Evolution and Ethics	John Dewey	57
Dynamic Homeostasis: A Unifying Principle in Organic, Social, and Ethical Evolution	Alfred E. Emerson	67
Philippine Fish Culture	Wallace E. McIntyre	86
The Scientific Measurement of Fitness for Self-Government	Stuart C. Dodd	94
Magnetic Storms, Aurorae, Ionosphere and Zodiacal Light	Edward O. Hulburt	100
On the Dynamics of Motion Sickness in a Seaway	Christopher C. Shaw	110
Book Reviews by C. A. Arnold, May Brodbeck, I. Bernard Cohen, Paul L. Errington, I. J. Gelb, James Gilluly, Bentley Glass, L. M. Graves, James B. Griffin, Garrett Hardin, Halford L. Hoskins, J. R. Kantor, Edward A. Kennard, George G. Lamb, S. B. Myers, Georg K. Neumann, Charles F. Peck, Jr., John R. Reid, Helen G. Rus- sell, George D. Stoddard, Sol Tax, Leslie A. White, and Albert Wolfson		117
Letter from Temple R. Hollcroft		128

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Science and Technology

(From the Month's News Releases)

Self-Leveling Step Ladder

A new automatic self-leveling step ladder for household and industrial use is now being manufactured. This safety ladder features a hinge that permits the ladder to stand firmly on uneven surfaces. It can't rock, twist, sway, or walk. (Richbilt Manufacturing Co., Dept. SM, 3277 Spring Grove Avenue, Cincinnati, Ohio.)

Anti-Foam Agent

An anti-foam agent can be sprayed from a push-button can to kill foam in chemicals and foods. Its effective concentrations of silicone usually range from 0.01 to 1.0 part per million, far less than the 10 parts per million permitted in foods by the Food and Drug Administration. In most cases, no trace of the aerosol mist can be detected in the finished product after defoaming. (Dow Corning Corporation, Dept. SM, Midland, Mich.)

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A new water demineralizer converts tap water to high purity water without the usual time lag between usage. The unit has a heavy steel outer shell made to withstand water pressure up to 100 lb, permitting the unit to be connected directly to a water source even when the outlet valve is turned off. In that way the unit retains a reserve of demineralized water ready for use at the turn of the valve. Though the water is under constant pressure, the unit's steel construction insures against the danger of ruptured cartridges and leakages. It operates on the ion-exchange principle and utilizes a replaceable cartridge filled with special resin substances which prevent minerals normally found in tap water from reaching the water outlet. (Palo Laboratory Supplies, Inc., Dept. SM, 81 Reade St., New York 7.)

Demonstrating Fluid Mechanics Unit

A comprehensive unit, that will expand college mechanical and aeronautical engineering laboratory facilities in the field of fluid mechanics, has been designed to help give a better understanding of the fundamentals of energy transfer and fluid flow encountered in axial-flow turbo-machinery. The packaged device is an adjustable-blade, multistage, axial-flow fan with a cradled d-c dynamometer. Experiments performed with the unit can be applicable to the basic fluid mechanics

of the multistage axial-flow compressor used in gas turbines. It also may be used in dynamometer absorption demonstrations as a prime mover driving other test machines, and as a low-pressure air supply of substantial volume for many types of laboratory test work. (General Electric, News Bureau, Dept. SM, Schenectady 5, N.Y.)

Sliding Doors

Sliding door units are available in closet and passageway types. Everything (except the trim) needed from the rough opening to the finished door is with the unit. A carpenter can install the units, using only a hammer, screwdriver, and level, in a matter of a few minutes. The doors are available in birch and gum. The closet units are made in 6' 8" and 7' heights, in nominal opening sizes of 32", 40", 48", 56", 60", 72", 84", and 96". The passageway units come in 6' 8" height, and widths of 24", 28", 30", 32", and 36". Step-by-step picture instructions are included in each package. (Haskelite Manufacturing Corporation, Dept. SM, Grand Rapids 2, Mich.)

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Automobile owners can have one mirror with two distinct mounting brackets. With one bracket the mirror can be mounted on the top edge of the car, and with the other it can be secured to the channel drain above the door. The mirror is suitable for mounting on the left or right side of most American-made passenger cars. A spring tension ball joint assembly makes it possible to adjust the mirror head to the needs of individual drivers and keeps it in position without the use of lock nuts or set screws. The 4-in. non-glare head is offset for maximum angle of adjustment and is easily replaced if damaged. (Yankee Metal Products Corporation, Dept. SM, Norwalk, Conn.)

Desk-Top Computers

Production of the first desk-top, electronic analog computers suitable for research laboratory or office use has been announced. Only 20 x 25 x 20 in. in size, they replace conventional computing equipment that normally occupies a 7-ft cabinet. The computers can solve differential equations or simulate physical systems up to the sixth order of magnitude. All mathematical operations are performed with better than 0.1 percent accuracy. Computing elements are matched to extremely close tolerances and are exceptionally stable. The new models are completely self-contained, with built-in supplies for amplifier and relay operation and an internal computing reference source. (Reeves Instrument Corporation, Dept. 4, 215 East 91 Street, New York 28.)

Catalytic Muffler

A new catalytic muffler has been designed to eliminate one of the major causes of smog—the hydrocarbons in the exhaust from automobile, bus, and truck

engines. Tests on the catalytic muffler, which is similar in size, shape, and location to the standard auto muffler, indicate that it can successfully eliminate the hazard of automobile exhaust gases in traffic-congested metropolitan areas. By chemical action of a special catalyst contained in the muffler, the unit burns the noxious hydrocarbons as well as carbon monoxide of engine exhaust to harmless carbon dioxide and water vapor. (Gray & Rogers, Dept. SM, 12 South Twelfth Street, Philadelphia 7, Pa.)

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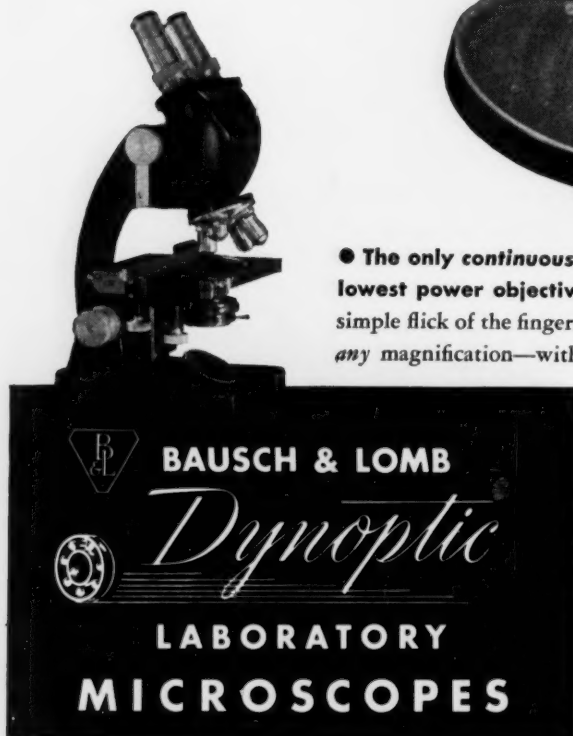
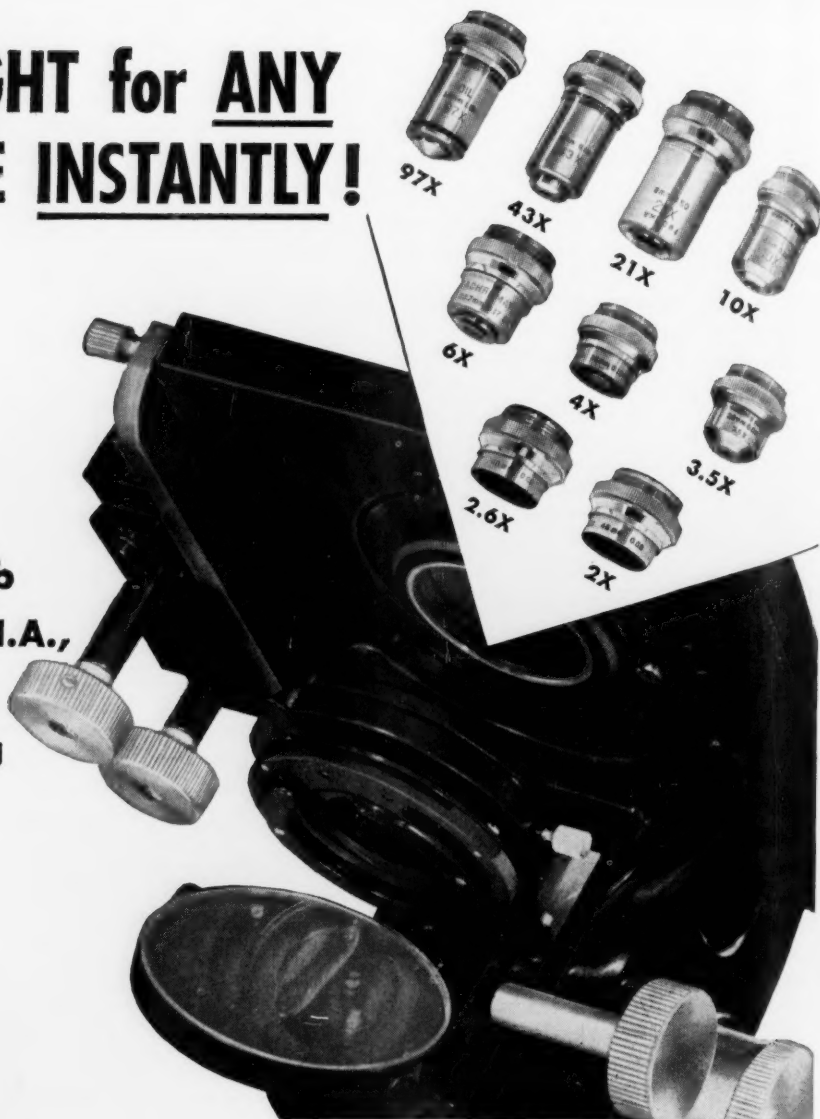
A new scintillometer (Fig. 2), developed particularly for use in geological survey work such as uranium prospecting, exploration for oil, and prospecting for non-radioactive minerals associated with uranium, is 290 times more sensitive than Geiger type counters. It is used for making production checks in radioactive ore processing and for field and laboratory radioactive ore assaying. Some nongeophysical uses of the scintillometer are civil defense radiation monitoring and personnel training, general health physics contamination monitoring, and isotope tracing in industry. The scintillometer rapidly and accurately detects and measures gamma radiation within wide limits under extended ranges of temperature and humidity. (The Radiac Company, Inc., Dept. SM, 489 Fifth Avenue (42nd Street), New York 17.)



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THE SCIENTIFIC MONTHLY

FEBRUARY 1954

Evolution and Ethics^{1*}

JOHN DEWEY

The reprinting of this penetrating essay by John Dewey, surely one of his very best, is well justified not only because it is half-forgotten and difficult to procure except in good libraries, but also and especially because one can find in it the germ of so many of the lines of thought fruitfully pursued by Alfred E. Emerson in the companion essay. It is good to take stock of the progress of thought in a particular field, of the history of particular ideas, especially in the light of the remarks made by John Dewey in his opening paragraph. Only in this way can we single out and appreciate the truly original. These two essays span a half-century of thought about the relation between evolutionary processes and the moral and ethical side of human life.—B.G.

TO A STRICTLY logical mind the method of the development of thought must be a perplexing, even irritating matter. Its course is not so much like the simple curve described by a bullet as it speeds its way to a mark, as it is like the devious tacking of a sail boat upon a heavy sea with changeable winds. It would be difficult to find a single problem during the whole record of reflective thought which has been pursued consistently until some definite result was reached. It generally happens that just as the problem becomes defined, and the order of battle is drawn, with contestants determined on each side, the whole scene changes; interest is transferred to another phase of the question, and the old problem is left apparently suspended in mid air. It is left, not because any satisfactory solution has been reached; but interest is exhausted. Another question which seems more important has claimed attention. If one, after a

generation or a century, reviews the controversy and finds that some consensus of judgment has finally been reached, he discovers that this has come about, not so much through exhaustive logical discussion, as through a change in men's points of view. The solution is psychologically, rather than logically, justified.

This general reflexion is called to mind as I undertake the discussion of the question of the relation of evolution and ethics. A generation ago the entire interest was in the exact relation between man and the lower animals. We had one school concerned with reducing this difference to the lowest possible limits and urging that the consciousness of man, intellectual and moral, as well as his physical nature, might be considered a direct inheritance through easy gradations from some form of the anthropoid ape. We had another school equally concerned with magnifying the difference, making it, if possible, an unbridgeable chasm. It would be a bold man who would say that this controversy has been settled by the actual weight of concrete detailed evidence, or even that it has been very far advanced. The writings which really throw light on the question, in either direction (so far as the facts are concerned and not merely general con-

¹ This paper was delivered as a public lecture during the Summer Quarter's work of the University of Chicago. This will account for the lack of reference to other articles bearing on the subject. I would call special attention, however, to Mr. Leslie Stephen on "Natural Selection and Ethics," in the *Contemporary Review*, and the article by Dr. Carus in *The Monist*, Vol. IV, No. 3, on "Ethics and the Cosmic Order."

* Reprinted from *The Monist*, Vol. VIII (1897-1901).

siderations), can probably be easily numbered on the fingers of the two hands. Yet suddenly we find that discussion of this question has practically ceased, and that what engages controversy is the relation of what I may call the evolutionary concepts in general to the ethical concepts. Points of agreement and disagreement between the ideas involved in the notion of evolution and those involved in the notion of moral conduct are searched for. It is the state of the imagination and the direction of interest which have changed.

It is the latter question which I purpose to discuss to-day. This particular phase of the problem was precipitated, if not initiated, by the late Professor Huxley in his Romanes lecture for 1893 on "Evolution and Ethics." It is some points in that address which I shall take as my text,—not for the sake of directly controverting them, but as convenient points of departure for raising the questions which seem to me fundamental. In that lecture, as you will all remember, Mr. Huxley points out in his incisive and sweeping language certain differences between what he terms the cosmic and the ethical processes. Those who recall the discussion following the lecture will remember that many felt as if they had received a blow knocking the breath out of their bodies. To some it appeared that Mr. Huxley had executed a sudden *volte-face* and had given up his belief in the unity of the evolutionary process, accepting the very dualistic idea of the separation between the animal and the human, against which he had previously directed so many hard blows. To some conservative thinkers it appeared that Saul had finally shown himself among the prophets. The lecture was deplored or welcomed according to the way one interpreted it with reference to his own prepossessions.

The position taken by Huxley, so far as it concerns us here, may be summed up as follows: The *rule* of the cosmic process is struggle and strife. The rule of the ethical process is sympathy and co-operation. The *end* of the cosmic process is the survival of the fittest; that of the ethical, the fitting of as many as possible to survive. Before the ethical tribunal the cosmic process stands condemned. The two processes are not only incompatible but even opposed to each other. "Social progress means the checking of the cosmic process at every step and the substitution for it of another, which may be called the ethical process; the end of which is not the survival of those who happen to be the fittest in respect of the whole of the conditions which exist, but of those who are ethically the best. The practice of that which is ethically best—which we call goodness or virtue—involves a course of conduct which

in all respects is opposed to that which leads to success in the cosmic struggle for existence. . . . The cosmic process has no sort of relation to moral ends. The imitation by man is inconsistent with the first principles of ethics. Let us understand once for all that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it." (*Ethics and Evolution*, pp. 81-83, *et passim*.)

Even in the lecture, however, Mr. Huxley used certain expressions which show that he did not hold to this opposition in a sense which meant the surrender of his previous evolutionary convictions. Thus he says that the ethical process, "strictly speaking, is part of the general cosmic process, just as the governor in a steam engine is part of the mechanism of the engine." (Note, p. 115.) In a later essay (published as *Prolegomena*), aroused somewhat by the clamour which the lecture had called forth, he makes his position even clearer. Here he illustrates his meaning by referring to the two hands as used in stretching or pulling. Each is opposed to the other, and yet both are manifestations of the same original force (p. 13). It is not that the ethical process is opposed to the entire cosmic process, but that *part* of the cosmic process which is maintained in the conduct of men in society, is radically opposed both in its methods and its aims to that *part* of the cosmic process which is exhibited in the stages of evolution prior to the appearance of socialised man upon the scene.

He makes this point clearer by reference to the analogy of a garden. (Pp., 9-11.) Through the cosmic process, independent of man, certain plants have taken possession of a piece of soil because they are adapted to that particular environment. Man enters and roots out these plants as noxious weeds, or at least as useless for his purposes. He introduces other plants agreeable to his own wants and aims, and proceeds at once to modify the environment; if necessary, changing the soil by fertilisation, building walls, altering conditions of sunlight and moisture so as to maintain his garden as a work of art—an artifice. This artificial structure, the one mediated by man's aims and efforts, is so opposed to the natural state of things that if man lets up in the ardor, the continuity, of his labors, the natural forces and conditions reassert themselves, the wall crumbles, the soil deteriorates, and the garden is finally once more overgrown with weeds.

Mr. Huxley is a trenchant writer, and his illustrations hold the mind captive. But possibly further consideration of this very illustration will point to a different conclusion. Illustrations are two-edged swords. There is no doubt in my mind of the just-



John Dewey, third from left, with some of his colleagues at Ann Arbor in the late nineteenth century.

ness of the analogy. The ethical process, like the activity of the gardener, is one of constant struggle. We can never allow things simply to go on of themselves. If we do, the result is retrogression. Oversight, vigilance, constant interference with conditions as they are, are necessary to maintain the ethical order, as they are to keep up the garden. The problem, however, is to locate this opposition and interference,—to interpret it, to say what it means in the light of our idea of the evolutionary process as a whole.

Thus considering the illustration, the thought suggests itself that we do not have here in reality a conflict of man as man with his entire natural environment. We have rather the modification by man of one part of the environment with reference to another part. Man does not set himself against the state of nature. He utilises one part of this state in order to control another part. It still holds that "nature is made better by no mean, but nature makes that mean." The plants which the gardener introduces, the vegetables and fruits he wishes to cultivate, may indeed be foreign to this particular environment; but they are not alien to man's environment as a whole. He introduces and maintains by art conditions of sunlight and moisture to which this particular plot of ground is unaccustomed; but these conditions fall within the wont and use of nature as a whole.

These may appear as too obvious considerations to be worth mentioning. Surely they could not have escaped Mr. Huxley for a moment. Yet it is possible that their bearing escaped him; for, if I mistake

not, when we allow our mind to dwell upon such considerations as these, the entire import of the illustration changes. We are led to conceive, not of the conflict between the garden and the gardener; between the natural process and the process of art dependent upon human consciousness and effort. Our attention is directed to the possibility of interpreting a narrow and limited environment in the light of a wider and more complete one,—of reading the possibilities of a part through its place in the whole. Human intelligence and effort intervene, not as opposing forces but as making this connexion. When Huxley says that "the macrocosm is pitted against the microcosm; that man is subduing nature to his higher ends; that the history of civilisation details the steps by which we have succeeded in building up an artificial world within the cosmos; that there lies within man a fund of energy operating intelligently and so far akin to that which pervades the universe that it is competent to influence and modify the cosmic process,"—he says to my mind that man is an organ of the cosmic process in effecting its *own* progress. This progress consists essentially in making over a part of the environment by relating it more intimately to the environment as a whole; not, once more, in man setting himself against that environment.

Huxley himself defines the issue in words already quoted in which he contrasts the survival of those who "may happen to be the fittest *in respect of the whole of the conditions which exist*, to the survival of those who are ethically the best." The clause italicised sums up the whole problem. It is granted

without argument that the fittest with respect to a limited part of the environment are not identical with the ethically best. Can we make this concession, however, when we have in mind the whole of the existing conditions? Is not the extent to which Mr. Huxley pushes his dualistic opposition, are not many of the popular contrasts between the natural and the ethical, results of taking a limited view of the conditions with respect to which the term "fit" is used? In cosmic nature, as Mr. Huxley says, what is fittest depends upon the conditions. If our hemisphere were to cool again, the "survival of the fittest might leave us with nothing but lichens, diatoms, and such microscopic organisms as that which gives red snow its color." We cannot work this idea one way without being willing to work it in the other. The conditions with respect to which the term "fit" must *now* be used include the existing social structure with all the habits, demands, and ideals which are found in it. If so, we have reason to conclude that the "fittest with respect to the whole of the conditions" is the best; that, indeed, the only standard we have of the best is the discovery of that which maintains these conditions in their integrity. The unfit is practically the anti-social.

Loose popular argument—Mr. Huxley himself hardly falls into the pit—is accustomed to suppose that if the principle of the struggle for existence and survival of the fittest were rigorously carried out, it would result in the destruction of the weak, the sickly, the defective, and the insane. An examination of this popular assumption may serve to illuminate the point just made. We are all familiar with Fiske's generalisation that civilisation is a product of the prolongation of the period of infancy; that the necessity of caring for offspring not able to take care of themselves, during a continually lengthening period, stimulated the affection and care, the moral germs of social life, and required the foresight and providence that were the germs of the industrial arts upon which society depends. Mr. Fiske's contention, whether true or false, is worth putting over against the popular assumption. How far are we to go in the destruction of the helpless and dependent in order that the "fit" may survive? Clearly in this case the infant was one who was "fit," not only in ethical terms but in terms of furthering the evolutionary process. Is there any reason to suppose that the dependent classes are not equally "fit" as present, when measured by the whole of the conditions as a standard?

We may imagine a leader in an early social group, when the question had arisen of putting to death the feeble, the sickly, and the aged, in order to give that group an advantage in the struggle for exist-

ence with other groups;—we may imagine him, I say, speaking as follows: "No. In order that we may secure this advantage, let us preserve these classes. It is true for the moment that they make an additional drain upon our resources, and an additional tax upon the energies which might otherwise be engaged in fighting our foes. But in looking after these helpless we shall develop habits of foresight and forethought, powers of looking before and after, tendencies to husband our means, which shall ultimately make us the most skilled in warfare. We shall foster habits of group loyalty, feelings of solidarity, which shall bind us together by such close ties that no social group which has not cultivated like feelings through caring for all its members, will be able to withstand us." In a word, such conduct would pay in the struggle for existence as well as be morally commendable.

If the group to which he spoke saw any way to tide over the immediate emergency, no one can gainsay the logic of this speech. Not only the prolongation of the period of dependence, but the multiplication of its forms, has meant historically increase of intelligent foresight and planning, and increase of the bonds of social unity. Who shall say that such qualities are not positive instruments in the struggle for existence, and that those who stimulate and call out such powers are not among those "fit to survive"? If the deer had never developed his timidity and skill in running away, the tiger and the wolf had never shown their full resources in the way of courage and power of attack. Again, prevention is better than cure, but it has been through trying to cure the sick that we have learned how to protect the well.

I have discussed this particular case in the hope of enlarging somewhat our conception of what is meant by the term "fit"; to suggest that we are in the habit of interpreting it with reference to an environment which long ago ceased to be. That which was fit among the animals is not fit among human beings, not merely because the animals were non-moral and man is moral; but because the conditions of life have changed, and because there is no way to define the term "fit" excepting through these conditions. The environment is now distinctly a social one, and the content of the term "fit" has to be made with reference to social adaptation. Moreover, the environment in which we now live is a changing and progressive one. Every one must have his fitness judged by the whole, including the anticipated change; not merely by reference to the conditions of to-day, because these may be gone tomorrow. If one is fitted simply to the present, he is not fitted to survive. He is sure to go under. A part of his fitness will consist in that very flexibility

which enables him to adjust himself without too much loss to sudden and unexpected changes in his surroundings. We have then no reason here to oppose the ethical process to the natural process. The demand is for those who are fit for the conditions of existence in one case as well as in the other. It is the conditions which have changed.²

Let us turn our attention from the idea of "fitness" to that of the process or method—the "struggle for existence." Is it true that in the moral sphere the struggle must cease, or that we must turn ourselves resolutely upon it, branding it as immoral? Or, as in the case of the idea of fitness, is this struggle as necessary to the ethical as it is to the biological? In reality, the idea of struggle for existence is controlled by the environment in which that struggle is put forth. That which is struggle for life, and successful struggle, at one time, would be inert supineness or suicidal mania at another. This is as true of varying periods in animal development as it is of the human contrasted with the animal. The nature of the struggle for existence is constantly modifying itself, not because something else is substituted for it, much less opposed to it; but because of the conditions of life change, the modes of living must change also. That which would count in the Carboniferous period will not count in the Neozoic. Why should we expect that which counts among the carnivora to count with man,—a social animal? If we do not find the same qualities effective (and hence to be maintained) in both cases; or if we find that opposed qualities are called for, what right have we to assume that what was once effected by the struggle for existence has now to be accomplished by another and opposed force?

The term "struggle for existence" seems to be used in two quite different senses by Mr. Huxley. In one case it means practically simply self-assertion. I do not see that the *struggle* for existence is anything more than living existence itself. Life tends to maintain itself because it is life. The particular acts which are put forth are the outcome of the life that is there; they are its expression, its manifestation.

Self-assertion in this sense carries with it no immoral connotation, unless life by its very nature is immortal. But Huxley also uses "struggle for existence" with a distinctly selfish meaning. He speaks

² Precisely it may be said, and that is just the reason that Mr. Huxley insists upon the opposition of the natural and the ethical. I cannot avoid believing that this is what Mr. Huxley really had in mind at the bottom of his consciousness. But what he says is not that the form and content of fitness, of struggle for existence, and of selection, change with the change of conditions, but that these concepts lose all applicability. And this is just the point under discussion.

of the "ape and tiger promptings" as branded with the name of sins. (P. 52). He identifies self-assertion with "the unscrupulous seizing upon all that can be grasped; the tenacious holding of all that can be kept." (P. 51.) It is "ruthless." It "thrusters aside or treads down all competitors." It "involves the gladiatorial theory of existence." (P. 82.) Hence it is a "powerful and tenacious enemy to the ethical." (P. 85.)

Surely, all this is rhetoric rather than philosophy or science. We inherit our impulses and our tendencies from our ancestors. These impulses and tendencies need to be modified. They need to be curbed and restrained. So much goes without saying. The question is regarding the nature of the modification; the nature of the restraint, and its relation to the original impulses of self-assertion. Surely, we do not want to suppress our animal inheritance; nor do we wish to restrain it absolutely,—that is, for the mere sake of restraint. It is not an enemy to the moral life, simply because without it no life is possible. Whatever is necessary to life we may fairly assume to have some relevancy to moral living. More than this is true. That self-assertion which we may call life is not only negatively, but positively a factor in the ethical process. What are courage, persistence, patience, enterprise, initiation, but forms of the self-assertion of those impulses which make up the life process? So much, I suppose, all would grant; but are temperance, chastity, benevolence, self-sacrifice itself, any less forms of self-assertion? Is not more, rather than less strength, involved in their exercise? Does the man who definitely and resolutely sets about obtaining some needed reform and with reference to that need sacrifices all the common comforts and luxuries of life, even for the time being social approval and reputation, fail in the exercise of self-assertion?

The simple fact of the case is of course that these promptings, even the promptings of the "tiger and the ape," are, simply as promptings, neither moral nor immoral; no more sins than they are saintly attributes. They are the basis and material of all acts whatsoever, good and bad. They become good when trained in a certain way, just as they become bad when trained in another way. The man who regards his animal inheritance as evil in and of itself apart from its relation to aims proposed by his intelligence, has logically but one recourse,—to seek Nirvana.³ With him the principle of self-

³ It is passing strange that Mr. Huxley should not have seen that the logical conclusion from his premises of this extreme opposition are just those which he has himself set forth with such literary power earlier in his essay, (pp. 63-68). That he did not shows, to my mind, how much he takes the opposition in a rhetorical, not a practical, sense.

negation becomes absolute. But with all others, the men and women whom Mr. Huxley is presumably addressing, self-restraint is simply a factor within self-assertion. It relates to the particular ways in which self-assertion is made.

I may appear here to have ignored Huxley's distinction between the struggle for existence and the struggle for happiness (p. 40). The former it will be said, he uses in a definite technical sense as meaning simply the struggle for the perpetuation of life, apart from the kind of life led, and as exhibiting itself in direct conflict with others, leading to the elimination of some. That struggle for existence it may be surely said, is not to be continued within the ethical process. The struggle for existence relates, he says, simply to the "means of living." Besides that we have the struggle for happiness, having to do with the uses to which these means are put,—the values which are got out of them, the ends.

I reply in the first place, that Mr. Huxley contradicts himself on this point in such a way that one would be quite justified in ignoring the distinction; and in the second place, that I am not able to see the validity of the distinction.

As to Mr. Huxley's self-contradiction, he asserts in a number of places that the struggle for existence as such (as distinct from the struggle for happiness) has now come to an end. It held only in the lower social forms when living was so precarious that people actually killed each other, if not for food, at least to secure the scanty store of food available. If it holds now at all it is simply among the small criminal class in society (p. 41). Now Mr. Huxley not only takes this position, but from a certain point of view is bound to take it. If the struggle is still going on, selection is still occurring, and there is every reason to suppose that as heretofore, it is a distinct agent in social progress; and Mr. Huxley is bound to hold that natural selection no longer operates in social progress and that therefore we must have recourse to other means. But if the struggle for existence has thus ceased of itself within any given human society, what sense is there in saying that it is now "a tenacious and powerful enemy with which ethical nature has to reckon"? If it has died out because of the change of conditions, why should the ethical process have to spend all its energy in combating it? "Let the dead bury their dead."⁴

In other words, Mr. Huxley himself is practically

⁴ Here is his flat contradiction: "Men in society are undoubtedly subject to the cosmic process. . . . The struggle for existence tends to eliminate those less fitted to adapt themselves to the circumstances of their existence" (p. 81). Compare this with pp. 15, 36, 38, and the other passages referred to above.

unable to limit the meaning of the phrase "struggle for existence" to this narrow import. He has himself to widen it so as to include not only the struggle for mere continuance of physical existence, but also whatever makes that life what it is. The distinction between the struggle for existence and the struggle for happiness breaks down. It breaks down, I take it, none the less in animal life itself than it does in social life. If the struggle for existence on the part of the wolf meant simply the struggle on his part to keep from dying, I do not doubt that the sheep would gladly have compromised at any time upon the basis of furnishing him with the necessary food—including even an occasional bowl of mutton broth. The fact is the wolf asserted himself as a wolf. It was not mere life he wished, but the life of the wolf. No agent can draw this distinction between desire for mere life and desire for happy life for himself; and no more can the spectator intelligently draw it for another.

What then is the conflict, the tension, which is a necessary factor in the moral life—for be it remembered there is no difference of opinion with Mr. Huxley upon this point? The sole question is whether the combat is between the ethical process as such, and the cosmic, natural, process as such. The outcome of our previous discussion is that it cannot be the latter because the natural process, the so-called inherited animal instincts and promptings, are not only the stimuli, but also the materials, of moral conduct. To weaken them absolutely, as distinct from giving them a definite turn or direction, is to lessen the efficiency of moral conduct. Where then does the struggle come in? Evidently in the particular turn or direction which is given to the powers of the animal nature making up the immediate content of self-assertion. But once more, what does this turn or direction mean? Simply, I take it, that an act which was once adapted to given conditions must now be adapted to other conditions. The effort, the struggle, is a name for the necessity of this re-adaptation.⁵ The conditions which originally called the power forth, which led to its "selection," under which it got its origin, and formation, have ceased to exist, not indeed, wholly, but in such part that the power is now more or less irrelevant. Indeed, it is not now a "power" in the sense of being a function which can without transformation operate successfully with reference to the whole set of existing conditions. Mr. Huxley states the whole case when he says that "in extreme cases man does his best to put an end to the survival of the fittest

⁵ I have developed this conception psychologically in the *Philosophical Review* for Jan. 1897, in an article upon the Psychology of Effort.

of former days by the axe and rope." The phrase, "the fittest of *former* days" contains the matter in a nut-shell. Just because the acts of which the promptings and impulses are the survival, were the fittest for by-gone days they are not the fittest now. The struggle comes, not in suppressing them nor in substituting something else for them; but in reconstructing them, in adapting them, so that they will function with reference to the existing situation.

This, I take it, is the truth, and the whole truth, contained in Mr. Huxley's opposition of the moral and the natural order. The tension is between an organ adjusted to a past state and the functioning required by present conditions. And this tension demands reconstruction. This opposition of the structure of the past and the deeds of the present is precisely that suggested in the discussion of the illustrative garden. The past environment is related to the present as a part to a whole. When animal life began on land, water became only one factor in the conditions of life, and the animal attitude towards it was changed. It certainly could not now get along without a water-environment, much less could it turn against it; but its relations to moisture as a condition of life were profoundly modified. An embryonic Huxley might then have argued that the future success of animal life depended upon combating the natural process which had previously maintained and furthered it. In reality the demand was, that which was only a part should be treated as such, and thus subordinated to the whole set of conditions.

Thus when Mr. Huxley says (p. 12) that "nature is always tending to reclaim that which her child, man, has borrowed from her and has arranged in combinations which are not those favored by the general cosmic process," this only means that the environment *minus* man is not the same environment as the one that includes man. In any other sense these "combinations" are favored by the general cosmic process,—in witness whereof man through whom that process works has set his sign and seal. That *if* you took man out of this process things would change, is much like saying that if they were different they would not be the same; or, that a part is not its own whole.

There are many signs that Mr. Huxley had Mr. Spencer in mind in many of his contentions; that what he is really aiming at is the supposition on the part of Mr. Spencer that the goal of evolution is a complete state of final adaptation in which all is peace and bliss and in which the pains of effort and of reconstruction are known no more. As against this insipid millennium, Mr. Huxley is certainly right in calling attention to the fact that the

ethical process implies continual struggle, conquest, and the defeats that go with conquest. But when Mr. Huxley asserts that the struggle is between the natural process and the ethical, we must part company with him. He seems to assert that in some far century it may be possible for the ape and the tiger to be so thoroughly subjugated by man that the "inveterate enemy of the moral process" shall finally be put under foot. Then the struggle will occur against the environment because of a shortage of food. But we must insist that Mr. Huxley is here falling into the very charges which he has brought against Mr. Spencer's school. The very highest habits and ideals which are organising to-day with reference to existing conditions will be just as much, and just as little, an obstacle to the moral conduct of man millions of years from now, as those of the ape and the tiger are to us. So far as they represent the survival of outworn conditions, they will demand re-constitution and re-adaptation, and that modification will be accompanied by pain. Growth always costs something. It costs the making over of the old in order to meet the demands of the new.

This struggle, then, is not more characteristic of the ethical process than it is of the biological. Long before man came upon the earth, long before any talk was heard of right and wrong, it happened that those who clung persistently to modes of action which were adapted to an environment that had passed away, were at a disadvantage in the struggle for existence, and tended to die out. The factors of the conflict upon which Mr. Huxley lays so much stress have been present ever since the beginning of life and will continue to be present as long as we live in a moving, and not a static world. What he insists upon is reconstruction and re-adaptation,—modification of the present with reference to the conditions of the future.

With the animal it was simply the happy guess, the chance. In society there is anticipation; with man it is the intelligent and controlled foresight, the necessity of maintaining the institutions which have come down to us, while we make over these institutions so that they serve changing conditions. To give up the institutions is chaos and anarchy; to maintain the institutions unchanged is death and fossilisation. The problem is the reconciliation of unbridled radicalism and inert conservatism, in a movement of reasonable reform. Psychologically the tension manifests itself as the conflict between habits and aims: a conflict necessary, so far as we can see, to the maintenance of conscious life. Without habits we can do nothing. Yet if habits become so fixed that they cannot be adapted to the ends suggested by new situations, they are barriers to

conduct and enemies to life. It is conflict with the end or ideal which keeps the habit working, a flexible and efficient instrument of action. Without this conflict with habits, the end becomes vague, empty, and sentimental. Defining it so that the habits may be utilised in realising it makes it of practical value. This definition would never occur were it not that habits resist it.

Just as habits and aims are co-operating factors in the maintenance of conscious experience, just as institutions and plans of reform are co-workers in our social life, just as the relative antagonism between the two is necessary to their valuable final co-adaptation; so impulse, call it animal if we will, and ideal, call it holy though we may, are mutually necessary in themselves and in their mutual opposition,—necessary for the ethical process. It is well for the ideal that it meet the opposition of the impulse, as it is for the animal prompting to be held to the function suggested by the ideal.

In locating and interpreting this tension, this opposition between the natural and the moral, I have done what I set out to do. There is one other point which it seems worth while to touch upon before leaving the matter. Three terms are always found together in all discussions of evolution,—natural selection, struggle for existence, and the fit. The latter two of these ideas we have discussed in their bearings upon moral life. It remains to say a word or two upon natural selection. Mr. Huxley's position on this point is not quite clear. As has been already suggested, it seems to be varying, if not actually self-contradictory. At times he seems to hold that since the struggle for existence has ceased in the social sphere, selection has ceased also to act, and therefore the work formerly done by it (if we may for the moment personify it as an agent) now has to be done in other ways. (See the passages referred to on p. 331.) At other times he seems to hold that it is still going on but that its tendency upon the whole is bad, judged from the ethical standpoint, and therefore requires to be consciously counteracted.

Certainly the question of the scope of selection in the sphere of social life is confused. Does it still continue or does it not? If it does operate, what are its modes of working? Many seem to suppose that we do not have it excepting where we intentionally isolate those whom we consider unfit, and prevent them from reproducing offspring; or that it is found only if we artificially regulate marriage in such a way as to attempt to select social and animal types considered higher at the expense of the lower. Mr. Huxley naturally considers selection in this sense, not only practically impossible, but intrinsically un-

desirable. But is this the only or the chief meaning of natural selection? Does it follow that social selection, to use a term employed by late writers, is something radically different from natural selection?

The belief that natural selection has ceased to operate rests upon the assumption that there is only one form of such selection: that where improvement is indirectly effected by the failure of species of a certain type to continue to reproduce; carrying with it as its correlative that certain variations continue to multiply, and finally come to possess the land. This ordeal by death is an extremely important phase of natural selection, so called. That it has been the chief form in pre-human life will be here admitted without discussion; though doubtless those having competent knowledge of details have good reason for qualifying this admission. However, to identify this procedure absolutely with selection seems to me to indicate a somewhat gross and narrow vision. Not only is one form of life as a whole selected at the expense of other forms, but one mode of action in the same individual is constantly selected at the expense of others. There is not only the trial by death, but there is the trial by the success or failure of special acts—the counterpart, I suppose, of physiological selection so called. We do not need to go here into the vexed question of the inheritance of acquired characters. We know that through what we call public opinion and education certain forms of action are constantly stimulated and encouraged, while other types are as constantly objected to, repressed, and punished. What difference in principle exists between this mediation of the acts of the individual by society and what is ordinarily called natural selection, I am unable to see. In each case there is the reaction of the conditions of life back into the agents in such a way as to modify the function of living. That in one case this modification takes place through changes in the structure of the organ, say the eye, requiring many generations to become active, while in the other case it operates within the life of one and the same individual, and affects the uses to which the eye is put rather than (so far as we can tell) the structure of the eye itself, is not a reason for refusing to use the term "natural selection." Or if we have limited that term to a narrower technical meaning, it is certainly no reason for refusing to say that the same kind of forces are at work bringing about the same sort of results. If we personify Nature, we may say that the influences of education and social approval and disapproval in modifying the behavior of the agent, mark simply the discovery on the part of Nature of a shorter and more economical form of selection than she

had previously known. The modification of structure is certainly not an end in itself. It is simply one device for changing function. If other means can be devised which do the work more efficiently, then so much the better. Certainly it marks a distinct gain to accomplish this modification in one and the same generation rather than to have to trust to the dying out of the series of forms through a sequence of generations. It is certainly implied in the idea of natural selection that the most effective modes of variation should themselves be finally selected.

But Mr. Huxley insists upon another distinction. Stated in terms of the garden illustration, it is that: "The tendency of the cosmic process is to bring about the adjustment of the forms of plant life to the current conditions; the tendency of the horticultural process is the adjustment of the needs of the forms of plant life which the gardener desires to raise." This is a very common antithesis. But is it as absolute and sweeping as we generally affect to believe? Every living form is dynamically, not simply statically, adapted to its environment. I mean by this it subjects conditions about it to its own needs. This is the very meaning of "adjustment"; it does not mean that the life-form passively accepts or submits to the conditions just as they are, but that it functionally subordinates these natural circumstances to its own food needs.

But this principle is of especial importance with reference to the forms in which are found the lines of progressive variation. It is, relatively speaking, true of the weeds and gorse of the patch of soil from which Mr. Huxley draws his illustration, that they are adjusted to current conditions. But that is simply because they mark the result, the relatively finished outcome of a given process of selection. They are arrested forms. Just because the patch has got into equilibrium with surrounding conditions progressive variation along that line has ceased. If this were all the life in existence, there would be no more evolution. Something, in other words, did *not* adapt itself to "current conditions," and so development continued.

It would be ungrateful in any discussion of this subject not to refer to Malthus's classis illustration of the feast spread by nature—not big enough for the invited guests. It is supposed, in its application to struggle for existence and selection, that this means that the life-forms present struggle just to get a share of the food that is already there. Such a struggle for a quota of food already in existence, might result, through selection, in perfecting a species already in existence, and thus in fixing it. It could not give rise to a new species. The selection which marks progress is that of a variation which

creates a new food supply or amplifies an old one. The advantage which the variation gives, if it tends towards a new species, is an organ which opens up a wider food environment, detects new supplies within the old, or which makes it possible to utilise as food something hitherto indifferent or alien. The greater the number of varieties on a given piece of soil, the more individuals that can maintain a vigorous life. *The new species means a new environment to which it adjusts itself without interfering with others.* So far as the progressive varieties are concerned, it is not in the least true that they simply adapt themselves to current conditions; evolution is a continued development of new conditions which are better suited to the needs of organisms than the old. The unwritten chapter in natural selection is that of the evolution of environments.

Now, in man we have this power of variation and consequent discovery and constitution of new environments set free. All biological process has been effected through this, and so every tendency which forms this power is selected; in man it reaches its climax. So far as the individual is concerned, the environment (the specific conditions which relate to his life) is highly variable at present. The growth of science, its application in invention to industrial life, the multiplication and acceleration of means of transportation and intercommunication, have created a peculiarly unstable environment. It shifts constantly within itself, or qualitatively, and as to its range, or quantitatively. Simply as an affair of nature, not of art (using these terms in Mr. Huxley's sense) it is a profitable, an advantageous thing that structural changes, if any occur, should not get too set. They would limit unduly the possibility of change in adaptation. In the present environment, flexibility of function, the enlargement of the range of uses to which one and the same organ, grossly considered, may be put, is a great, almost the supreme, condition of success. As such, any change in that direction is a favorable variation which must be selected. In a word, the difference between man and animal is not that selection has ceased, but that selection along the line of variations which enlarge and intensify the environment is active as never before.

We reach precisely the same conclusion with respect to "selection" that we have reached with reference to the cognate ideas—"fit" and "struggle for existence." It is found in the ethical process as it is in the cosmic, and it operates in the same way. So far as conditions have changed, so far as the environment is indefinitely more complex, wider, and more variable, so far of necessity and as a

biological and cosmic matter, not merely an ethical one, the functions selected differ.

There are no doubt sufficiently profound distinctions between the ethical process and the cosmic process as it existed prior to man and to the formation of human society. So far as I know, however, all of these differences are summed up in the fact that the process and the forces bound up with the cosmic have come to consciousness in man. That which was instinct in the animal is conscious impulse in man. That which was "tendency to vary" in the animal is conscious foresight in man. That which was unconscious adaptation and survival in the animal, taking place by the "cut and try" method until it worked itself out, is with man conscious deliberation and experimentation. That this transfer from unconsciousness to consciousness has immense importance, need hardly be argued. It is enough to say that it means the whole distinction

of the moral from the unmoral. We have, however, no reason to suppose that the cosmic process has become arrested or that some new force has supervened to struggle against the cosmic. Some theologians and moralists, to be sure, welcomed Huxley's apparent return to the idea of a dualism between the cosmic and the ethical as likely to inure favorably to the spiritual life. But I question whether the spiritual life does not get its surest and most ample guarantees when it is learned that the laws and conditions of righteousness are implicated in the working processes of the universe; when it is found that man in his conscious struggles, in his doubts, temptations, and defeats, in his aspirations and successes, is moved on and buoyed up by the forces which have developed nature; and that in this moral struggle he acts not as a mere individual but as an organ in maintaining and carrying forward the universal process.



There were two age-old tendencies toward stagnation in scientific thought which those of youthful spirit had always to resist. One was the human weakness of accepting the uncorroborated say-so of eminent authorities, and the other was the human stupidity of regarding natural science as something divisible into watertight compartments. Of course it was contended that such compartments, labelled Chemistry, Mycology, Bacteriology, etcetera, were never really fish-tanks for myopic specialists to swim about in, but merely convenient departments in one splendid and sunlit edifice of science, separated at the most by glass walls, decorated with the flags of all nations, and provided with innumerable intercommunicating doors. If so many stacks of old scientific papers got piled up on each side of the glass partitions that in the end no one could see through them, that was certainly regrettable; and if some of the doors were locked for periods ranging from a decade to a century, well, that also was a pity—but who wanted to work in a draught?—E. C. Large, *The Advance of the Fungi* (Henry Holt & Co., 1940), p. 317.

Dynamic Homeostasis: A Unifying Principle in Organic, Social, and Ethical Evolution *

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MUCH controversy occurs concerning the application of methods and principles from the natural sciences to the humanities and social sciences. Although sciences are divided according to their subject matter, they all use a logical method for the attainment of self-correcting knowledge, and the method may be applied to a great variety of fields of inquiry. The essential principles of the scientific method are: observation by means of sensory perception, classification of related facts, determination of causes and effects and the formulation of theoretical interpretations in conformity to the facts and their relations, the verification of relevant facts, and finally, the reporting of facts, relationships, and interpretations in order that others may criticize, modify, and correct the data and the conclusions.

There would seem to be no valid reason why

* This is an expansion and revision of Chapter X in *Goals of Economic Life*, Harper and Brothers, New York, 1953, reproduced here with the permission of the publisher. This book resulted from conferences of a study committee of The Federal Council of Churches under the chairmanship of A. D. Ward. I am obligated to this group for critical discussion and, more recently, to the conference group on The Unified Theory of Human Nature under the chairmanship of Roy Grinker, Michael Reese Hospital, Chicago. I also owe much of my thinking on this subject to my long personal friendships with W. C. Allee and Ralph W. Gerard.

symbols, culture, and ethics cannot be studied by the scientific method.^{1,2} It is true that science is based upon objective data, whereas ethics may arise in part from subjective feelings, but subjective data may be objectivized and analyzed. Psychologists constantly treat subjective emotions scientifically. The origins and the effects of subjective attitudes may be studied by the objective methods of psychological and social science, in large part the same methods that are used in natural science. Subjective concepts and emotions give rise to behavior in both animals and man. Both observation and experiment indicate that areas in the brain (hypothalamus) control emotional expressions such as anger and fear, while maternal care is controlled by other areas (cerebrum). It also has been demonstrated that hormones may affect behavior and in turn may be affected by emotions. There is no longer any question that emotions influence thinking and that they respond in turn to the intellectual activity of the cerebral cortex. Psychosomatic medicine and hypnosis have demonstrated the relation between learned behavior and the physiology of the body. Scientific thinking cannot divorce itself from human emotions and human nature, but it can gradually discover the relations and interdependence of objective and subjective manifestations.

There are some who feel that so-called cold-

blooded scientific analysis takes away the response to beauty and the esthetic delight inherent in art and religion. The philosophy of esthetics is still in a crude form. However, there is some reason to think that the recognition of order and harmony in thought and ideas as well as in nature and the works of man may give rise to emotional pleasure akin to that derived from other forms of beauty. The motivation from esthetic emotions stimulates the scientist and the humanist alike.

Many scientists would not agree with some of the above statements and would take the position that ethics, value, and beauty are not subject to scientific investigation. The contention of this essay is that a partial understanding of value systems is possible through scientific method. Numerous modern scientists advocate a scientific approach to ethics, a position that may be referred to as *Naturalistic Ethics*.³

Man tends to rationalize his subjective attitudes. Ethical statements often are used to cover up more basic motivations and feelings. This conscious or unconscious hypocrisy is not dealt with in detail here. It is thought best to confine this discussion to ethics as it initiates and controls human behavior and social coordination. The psychological aspects of ethics are important but are left for further analysis to the psychologists. Knowledge of personality development is highly pertinent to the ensuing discussion, but time, space, and the competence of the author do not justify its inclusion.

Because of the complexity of society, we may expect to find the scientific methods used in biology applicable to the social sciences rather than those used in the physical sciences. Biology handles intricate data and concepts. Neither biology nor ethics can ever become an exact science with rigid mathematical formulation or prediction. If a few factors influence a repeated event and these can be quantified, mathematical formulation and prediction are possible. In biology and the social sciences, however, a great many factors usually affect any given event, and these are seldom completely known or evaluated. In spite of the complexity of the subject matter, biology has made great advances in understanding and in controlling life processes. Progress in agriculture and in medicine demonstrate the applicability of basic biological science to complex activities and events. There would seem to be no intrinsic reason why social science, including the humanities and ethics, may not be expected to advance and to find applications in some measure commensurate with the rapid development of the biological sciences.

We should not expect to find absolute truth by

means of the scientific method. Unproved and possibly unprovable assumptions are fundamental to scientific method, for example, the validity of sensory perception in bringing us into contact with reality. Relations of sensory experience are basic to the logic of science and all scientific truth is therefore relative. So, likewise, our scientific knowledge of social science and ethics will remain relative and will never become absolute.⁴

Philosophical considerations, possibly beyond the scope of science, produce much argument and controversy. For example, the relation of "is" to "ought," if any, underlies any science of ethics.⁵ Without attempting to settle this ancient problem, it seems that value systems and attitudes evolve and are directed by dynamics similar to those found in biological systems, and that our philosophical difficulties are more semantic than scientifically real.⁶

Certain biological principles are found to be transferable to social science. Biology and anthropology have clearly demonstrated that man has evolved directly from certain higher animals. Not only do his body and mental faculties show relationship to his primate relatives, but his society is based upon mammalian group behavior, particularly family group behavior. These comparisons may assist us in understanding fundamental principles of societal coordination. For example, a social hierarchy founded upon dominance and subordination learned through individual contacts is characteristic of many vertebrates, particularly in flocks of birds and in herds of mammals. A similar social hierarchy seems to be characteristic of man in his various social organizations.^{7, 8} The background of vertebrate group behavior should not be relied upon exclusively for a science of society. Insects also have evolved complex societies that illustrate certain social activities, for example, shelter building and agriculture.⁹ Division of labor among adult individuals of the same sex is characteristic of insects and humans, but is only vaguely discernible in the subhuman mammals.

We may conclude, therefore, that intricate social behavior evolves and is an expansion of biological antecedents, and biology should be able to supply us with basic principles underlying social coordination. There are many unique characteristics of the societies of man, particularly those associated with language. Biology does not deal directly with social phenomena that are dependent upon symbolization. But these unique qualities do not prove the lack of fundamental connecting principles between the social and natural sciences. Probably the study of the great bulk of human activities will properly remain within the field of the social sciences, and

biologists will only assist in laying foundations upon which the social scientist can build. Several intermediate sciences, particularly human geography, psychology, anthropology, and mathematics investigate and relate both natural and cultural phenomena. On occasion the biologist may use principles discovered by the social scientist. The concept of division of labor between parts of a whole now found universally applicable to all living things was first enunciated by students of human society.

Homology and Analogy

If we agree that scientific method and concepts as used in the complex biological sciences may be applicable to the study of ethics, we must validate the use of analogy. No biological group with the exception of social man possesses an ethics based upon communication by symbols; therefore, the comparison of ethical man to any other living system is through analogy. We may briefly state that comparative resemblances are classified into three types: fortuitous, homologous, and analogous.

In the case of fortuitous resemblance the correlations of observed facts indicate no incidence beyond that expected by chance, and no cause and effect relations can be established. Sympathetic magic* and astrology may be cited as widely held beliefs of causation with little or no indication of any significant correlations beyond those that may be attributed to chance.

Comparisons of homologues are used frequently in biology and are fundamental to much of our knowledge. Homologues are similar because they possess the same intrinsic cause and effect relations. For example, the eyes of a gorilla, a chimpanzee, and a man are considered homologous because the data on the structure, physiology, and development of the eyes of these animals are interpreted as indicating that identical genes or gene parts (self-replicating organic molecules) initiate identical developmental processes that result in an identity of growth and physiological function. These genes, in all probability, were present in the common ancestor of the gorilla, chimpanzee, and man, and have been passed from generation to generation through millions of years.

Illustrative homologues usually have only a proportion of identity that seldom reaches one hundred percent. In consequence, differences occur associated with homologous similarities, and complete identity of compared organs or systems is rare.

In the study of ethics, we may apply the concept

* Sympathetic magic involves the attempt to injure a person by injuring his image. Hanging in effigy is a related modern custom.

of homology to similarities of ethical practice with the same origin under the same guiding forces and passed from one individual to another by means of the same symbols with the same meanings. For example, similarities of ethics in different Christian sects may be considered socially homologous if they can be traced to the same historical source.

Biological analogy refers to functional resemblances arising independently of each other through the action of natural selection on different genetic systems. Analogous similarities are neither fortuitous nor homologous, but they appear through the action of similar extrinsic or environmental guiding forces. For example, the eye of an insect and the eye of a man have similarity in their image-perceiving function, but there is no evidence that any genes initiating eye development are the same in these two forms. The ancestral animals common to both types (primitive bilateral unsegmented worms) certainly did not possess an image-perceiving eye, and the development and physiology are very different in spite of the functional resemblance that is recognized by the use of the word eye. Analogues in biological systems are the result of convergent adaptive evolution—a principle that will be briefly mentioned later.

A complex structure or process may have both homologous and analogous traits at the same time, and these may be difficult to separate in all cases. On the other hand, homology and analogy may be easily separated in certain instances. In the classical case of the wing of a bird and the wing of a bat, all the structure, physiology, development, and genetics that pertain to the function of flight are clearly analogous, while all the basic structure, physiology, development, and genetics of the forelimb that are continuous in evolution and that occurred in the common ancestral reptile are clearly homologous.

Much of biological science is founded upon comparisons of analogues. It need only be stated that many genes are analogues; different hormones in the vertebrate body are analogues; sex determination mechanisms in trees, insects, and man are analogues; the multicellular individual sponge, vertebrate, and plant are analogues; and the societies of termites, ants, and men are analogues. In none of these compared categories are the similarities the result of identical protoplasmic self-duplicating mechanisms derived from identical ancestors possessing the compared characteristic. It is obvious that comparisons of analogues are basic to important sciences, including genetics, endocrinology, sex biology, the study of organismic systems, and comparative sociology.

Only general resemblances between analogues should be expected. Significant analogues often lack close similarity of detail. Because of the expected limitations in the degree of identity between analogues, extrapolation from one to another has definite restrictions.^{10, 28} One cannot presume that two analogues necessarily possess common traits or principles of organization without comparative facts and significant correlations. But the possession of similarities in independently derived systems substantiates the concept of analogy and stimulates inquiry into the causes of the resemblances. The more distantly related the compared phenomena are, the more difficult it is to recognize shared causation, but at the same time the more fundamental and important is the discovered principle.

Critics of analogical reasoning are concerned over its use for certain false conclusions.¹¹ It is true that there are many examples of naive associations and even dangerous thinking resulting from false analogical comparisons. For example, from the fact that the joint efforts of worker bees produce a hive for the colony, the assumption that the hive is common property is not wholly justified and should not be used as an argument favoring socialism, communism, or the totalitarian state. Political systems are in a large measure the result of learned language communication and cultural evolution. Ascribing a similarity of detail (the human concept of private or public property) to a political system and to a genetic system is hardly valid. We may find that the function of political systems in human society has a general analogy to the genetic integration of social insects, but we must be careful not to carry the analogy into details that may be based upon verbalisms. Arguments by false analogy have been used to justify social bias. Rationalization of subjective prejudice is not scientific. Science is objective. Scientists, with the foibles of other humans, are often subjective in their opinions. The danger is real that scientists will rationalize their prejudices by the use of false analogical reasoning under the guise of purported scientific method. It is hoped that this "ethnocentric" danger has been avoided here.

A common example of the use of false analogy is found in the anthropomorphic explanations of animal behavior. Hardly any anecdote told by the owner of a pet is free from the tendency to humanize the beloved animal. And there is also a trend among students of social insects to "termitomorphize" or "myrmecomorphize" human society and to make humans falsely resemble termites or ants. Part of the difficulty is to be found in the limitations of our language. A term that originally has had human con-

notations is applied to animal behavior and utilized as if it had significant meaning for both humans and animals. A term with double meaning may be used with a shift of the meaning in different contexts, thus confusing the analysis. Semantic ambiguities often produce what seem to be divergent opinions and conclusions that could be resolved with a clarification of terms. Verbalisms and euphonious metaphors may often prove to be false analogies. Analogy is valuable in scientific comparisons, but only when relative functional resemblance can be demonstrated.

All analogues with similarities of function also have differences of exact mechanism, and these should be clarified. Because of convergent evolution, analogues are expected to have fundamental differences and an understanding of these assists in the analysis of the nature and causation of the similarities. An understanding of any system demands comparative information on both the similarities and differences between it and other systems.¹²

Even though no nonhuman group of organisms possesses an ethics, if ethics in any way has a functional resemblance to biological activities, analogous comparisons may be made and interpretations proposed. A comparative study of cultural patterns and systems may be expected to reveal fortuitous, homologous, and analogous similarities, and these may be objectively studied and measured. Significant resemblance between ethics and any subhuman biological processes is largely if not wholly analogous.

Analogy Between Cultural and Biological Systems

The reason why culture is confined to humans seems obvious. Man constitutes the only species that has attained communication through learned symbols that can be transmitted from one individual to another and from one generation to another. Consequently it is possible to acquire socially the experience and thoughts of another individual through the transmission of meaningful words and objects. Ethics is composed of the concepts and customs dealing with right and wrong, good and bad, and is socially inherited by means of symbolic expressions.

Biological inheritance is made possible through the transmission of genes. Genes are considered to be self-replicating nucleic acid or nucleoprotein molecules, each different one distinctive in its influence on enzymic action. Human social or cultural inheritance is made possible through the transmission of symbols—usually spoken or written language. Social contact and contiguity is necessary for social inheritance. Germinal contact and con-

tinuity is necessary for biological inheritance. Symbols have meanings that are learned. They are duplicated by each new individual as they are learned from others, and each symbol may initiate associated behavior. Biological and social inheritance are analogues with fundamental differences in mechanisms and fundamental similarities in their hereditary function.

Genes not only function in the repetition of inherited characters but they also are capable of changing or mutating, and these changes are also inherited. Mutability, or modifiability, is characteristic of genes. This genetic variability is a necessity for much subsequent evolution. Symbols repeat their function in individuals to whom they have been transmitted and who have learned their meanings. Duplication and the repeated initiation of homologous activity are not the only functional analogies between genes and symbols. Symbols also are able to become modified and to pass on as modified to other individuals. Modification of symbolic meanings seems to be a necessity for progressive social evolution in man. A rigid invariant system of symbols passed from one generation to another would be social inheritance but it would prevent progress. Any attempt to establish a fixed and unchanging pattern of symbols and ideas is consequently unprogressive. Here we may begin to discern an important difference in emphasis between democratic and authoritarian political philosophies, between freedom of expression and inquiry as contrasted to a stereotyped ideology established by uncritical adherence to repeated slogans. Freedom of the individual is the basis of criticism and new adjustments, and no political regime has lasted that has so restricted individual freedom that it has negated the possibility of reform.

Gene mutations are nearly always haphazard in the adaptive direction of their effect. In contrast, modification of symbols by means of human intelligence and reason often produces a directed adaptive response. Humans not only intelligently direct the change in symbols but they create new symbols to express new meanings and initiate new directional responses. There would seem to be little question that a part of the uniqueness of human social evolution rests upon this important difference from biological evolution. The difference in the rate of the two types of evolution is largely to be explained by this principle. With new discoveries, behavior may change conspicuously as the symbols are communicated by personal contact or by publication or radio. Nonhuman animals may learn individually and also may reason, but their evolution depends upon genetic change, fixation, and dispersion, and

these events take a long time. Therefore we find organic evolution takes many thousands or millions of years before important new adjustments are produced, whereas social evolution is possible over a few years or decades.

The two functions of genes, the repetition and duplication leading to inheritance and the capacity to mutate, result in a compromise between the two. Too much change would destroy inheritance and would result in the loss of accumulated adaptation. Too little change would prevent evolutionary advancement. Genes have evolved toward a balance between these somewhat opposed functions. This balance is termed mutation pressure by biologists. Symbols also probably have evolved toward a balanced regulation of these analogous functions. This trend, if it exists, needs exacting study.

Genes have a unitary attribute that includes a degree of individual independence. Each gene may be naturally selected and sorted somewhat independently according to the efficiency of its function. Complex organic adaptations are always the result of a gene pattern composed of many genes, each functioning under different physiological and developmental conditions to produce a synthetic beneficial result. There seems to be no doubt that symbols also are always grouped and function in organized systems. At the same time, they possess a degree of independence.

One gene may have numerous effects in different physiological settings. It seems obvious that symbols also vary in their effect in different combinations with other symbols and in different social settings. The differences in the meaning of the same word in different contexts is a simple example of this principle as it operates in a cultural system.

Characters of organisms are dependent on many genes. Functional symbolic systems also are dependent upon multiple symbols, each of which can also function in other directions.

Recombination of genes into new patterns is a basic cause of genetic variability. Recombination is the original function of sex in plants and animals. Organized recombination of symbols may also profoundly influence the evolution of symbolic systems including ethics. The science of ethics will probably find some significant analogy to sexual fusion. Our common use of the term cross-fertilization is indicative of such an analogue.

We may predict that changes in patterns may produce novelties in both gene and symbol systems. The concept of emergent evolution emphasizes new properties emerging from new associations. As a matter of fact, it is hoped that this essay will pro-

duce some emergent concepts from the cross-fertilization of natural and social science.

Individual organisms are integrated by a variety of biological mechanisms, biochemical and biophysical, that are predominantly dependent upon protoplasmic continuity or contiguity. Intraspecies populations are integrated by genetic continuity, by biochemical agents, and especially by sensory stimulus and response affecting behavior. Population integration is not dependent upon protoplasmic contact except for the reproduction of individuals.

Behavior may be learned or instinctive (genetically initiated). Learned behavior is predominant in humans and learned symbols are practically unique. Ethics is an important aspect of learned symbolic communication integrating human populations and groups. It is analogous to population and organismic integrative mechanisms in non-human animals. Learned ethical behavior is both one of the causes and one of the effects of human social unity.

Biological organisms and populations show development in time (ontogeny or life history) and evolution in time (phylogeny). Genes and gene patterns may have sequential effects in the life history of the individual. Distinctive adaptive traits associated with age may evolve in animals or plants, for example, in the different stages of the mosquito development, or the special adaptations of a seed in contrast to those of the mature plants. Populations often exhibit life cycles of the group as a whole (malarial protozoans, tape worms, aphids) with physiological and psychological functions distinctive in the different generations within the population.

Both individual and population characters have evolved through time with genetic modification during phylogeny. Ethics, as a primary integrative mechanism of human populations, may be expected to have these time dimensions. One may expect a development of ethical concepts from childhood to maturity, and a different ethics for children than for adults. Not only is there an individual development of ethical attitudes, but there is an evolution of ethics through racial experience and cultural transmission from one generation to another.

Cultural accumulation by means of symbols is confined to humans so that social evolution builds upon the past experience of the species. In contrast, organic evolution builds upon the past accumulation of genetic units and systems.

Functional Relations of Organic and Social Systems

Efficiency demands a degree of specialization, and all life now existing exhibits specialization of

function among the parts. Division of labor is found among individuals in population systems, particularly in truly social animals. Natural selection sorts more efficient mechanisms for survival, and the less efficient may be eliminated. The result is a general increase in division of labor during both development and evolution. The psychological division of labor within human society that results from the learning of special skills shows a relation to the time factor of both individual and group development and evolution. Spencer and others emphasized evolutionary increase in complexity and integration. Recent evolutionary study indicates the validity of these trends in most sequences, but if either complexity or integration are considered ends in themselves, false conclusions may result.

Division of labor and integration are reciprocal principles and are always associated. Specialized function has no utility if the parts are not brought into coordinate relationship and incorporated into a larger unit. And this unit is the result of the interaction of the parts.

Various levels of integration with division of labor among the parts are found. Some of these living systems may be listed as follows:

1. Cells with protoplasmic parts.
2. Multicellular organisms with cellular parts.
3. Intraspecies populations: (a) intrabreeding populations with male and female individuals; (b) family groups with parental care of the offspring; (c) societies with division of labor extending beyond the sexual and family level among the mature individuals.
4. Interspecies groups: (a) man together with his domesticated animals and plants (a biocenose); (b) associated organisms incorporated with their definitive habitats (an ecosystem).

In all levels of interaction we find parts functioning toward the coordination of the more inclusive unity. Many types and gradations of mechanisms leading toward integration may be found. These mechanisms are often analogous in different organismic systems (see Simpson⁴ and Schneirla⁵ for critiques of the social supraorganism, and Emerson¹⁰ for an analysis of the concept).

In human society, integration is attained by numerous devices, including esthetics, ethics, religion, economics, government, and education. The social institutions and customs are used to enhance, develop, and channelize the basic virtues of love, loyalty, mutual sympathy, and constructive competition. Destructive competition, hatred, and social vices may also be increased through social integration but, in the long run, inefficiencies tend to be

eliminated and functional efficiencies tend to be perpetuated. Competition is not always disintegrative, nor is cooperation always integrative.

Division of labor and integration are not ends in themselves. In order to evolve progressively, they must produce greater functional efficiency. The maintenance and control of the necessities of life at optimal values for efficient existence seem to be a universal evolutionary trend. Self-control, regulation, and maintenance of many important conditions of life within each organismic level or system has been termed homeostasis by the great Harvard physiologist, Walter Cannon.^{13, 14} Homeostasis within the human body includes the regulation of water, sugar, salts, and temperature, to mention only a few examples. Relative equilibrium within narrow ranges of variation, and balanced compromise among multitudinous activities are characteristic of homeostasis. Homeostasis may be a delicate regulation by means of subtle mechanisms, as well as a grosser and more obvious control. It may be psychological as well as physiological. It may involve activation or inhibition. Homeostatic effects are often web effects with many feed-backs. There may be homeostasis of homeostatic mechanisms.

Homeostasis is not static but is dynamic. Functional differentials and unbalance may be homeostatic. For example, the nerve impulse is a wave of depolarization of the nerve membrane. Repolarization is rapid, thus maintaining the functional capacity of the nerve. The maintenance of polarization in this case is the homeostatic establishment of disequilibrium. Optimal conditions of life and existence often require differentials, asymmetries, and variation, rather than uniformity, symmetry, and stability. Homeostasis is the regulation, control, and maintenance of conditions for optimal existence (Cannon¹³ and Gerard¹⁵ discuss both physiological and social homeostasis; Emerson^{10, 16} discusses evolutionary implications).

Homeostasis of population systems is characteristic of animal groups. It may be observed in the activities leading to group protection from predators, regulation of food resources, and shelter construction. What appears to be individual competition and combat may be group homeostasis. Survival of the species may depend upon efficiency in the spacing of feeding and mating activities. We find animals fighting in defense of mates, nesting sites, and feeding territories. The size of the group in relation to the efficiency of biological activities is important and is often controlled and regulated. Homeostasis may involve an optimal population size rather than minimal or maximal numbers.

Homeostasis within human society includes the

social regulation of optimal physical and biotic conditions of human existence by means of architecture, industry, transportation, agriculture, public health, and economic exchange, to mention only a few aspects of social balance and control. Innumerable aspects of social life may have optimal values. These values, at least in part, may be measured and partially determined. Although the more obvious regulations are used to illustrate the principle, for example, the control of temperature in buildings, the control of the food supply through agriculture and distribution, the control of exchange through transportation, and the control of health through medicine, there is no doubt that a very large number of social variables may become homeostatic. Social research will doubtless discover many subtle aspects of balance and dynamic regulation in multiple social interactions. The roles of music, art, literature, religion, and entertainment have not been fully evaluated in terms of advancing civilization, but there is good reason to believe that a balanced life includes a proportion of time devoted to many activities—physical, esthetic, intellectual, "spiritual," social, and relaxing. Humor seems to assist in personal and social integration and balance, but its function in human coordination is only vaguely understood. The gaps in our knowledge of homeostasis, particularly psychological and social homeostasis, demand much further investigation.

Homeostasis of one functional activity may interfere with another both within the individual organism and within the integrated group system. Balanced adjustment evolves. A degree of separation may reduce the interference. This separation may be chronological or spatial, quantitative or qualitative. Such periodicities, replications, and specializations are characteristic of all integrative levels.

We may conclude from the accumulation of great quantities of evidence that the general long-term trend of all social and organic evolution is toward increased homeostasis, and that ethics and economics are important portions of the process in human social evolution. Many terms and phrases carry implications of homeostasis and indicate that this concept is old. These include such words and phrases as beneficial, well-being, adaptation, adjustment, welfare, security, harmony, equilibrium, balance, the good life, satisfaction, prosperity, enrichment, self-fulfillment, the full life, self-sufficiency, progress, the greatest good for the greatest number, self-control, peace of mind, contentment, and happiness. Many of these terms have ethical connotations. Dynamic homeostasis has an impor-

tant advantage over nearly all these terms. It can be observed and measured in living systems. It enables us with some accuracy to compare different analogous levels of integration. It enables us to recognize the general temporal trend of all surviving life that until recently has been obscure.

Organic, Social, and Ethical Evolution

The three fundamental factorial complexes that combine to produce progressive organic evolution are genetic variation, reproductive isolation, and natural selection.²³ In the evolution of any social system we must also expect social variability, a degree of social isolation, and selective assortment of the most efficient social characteristics producing homeostasis.

In organic evolution, genetic variation occurs by means of mutation and sexual recombination. In social evolution, it is suggested that new discoveries and new ideas are roughly analogous to mutations, and that new arrangements and organizations of ideas and concepts are analogous to biological recombination. Both produce a variability that is a necessary prelude to any evolutionary change.

In its initial appearance, variation is likely to be unadjusted and is often deleterious in its effect. To arrive at functional adaptation, other factors must operate. However, any social tendency drastically to restrict variation in ideas and actions may result in an unprogressive stabilization of the system.

Organisms and social systems are too complex ever to expect perfection of adjustment, either now or in the future. There is always room for improvement and new adjustments are always necessary to meet the constantly changing environment. Therefore, any restriction of evolution by means of a gross limitation of variation and creativeness results in retrograde motion relative to other freer competing systems.

We now begin to detect the role of individual freedom in the evolutionary advance of society. Freedom of opportunity, freedom of speech, and freedom of inquiry are essential forms of controlled variability necessary to social progress. Individual enterprise may be a trial and error mechanism with commensurate reward for ingenuity, initiative, and skill in business or in other human activities, for instance, in scientific research and in the creative arts. Individual enterprise in social exploitation, however, is not ethical if it rewards cleverness directed toward antisocial objectives. Social pressures that inhibit or prevent such individual enterprise are ethical if the result of freedom is a decrease

in social health and social homeostasis, a waste of human energy, and an economic exploitation of the ignorant and gullible. Initiative and cleverness are not virtues in themselves. They may be deemed virtues only when they are directed toward individual and social progress. And progress means an increase in individual, social, and ecological homeostasis.

In organic evolution, reproductive isolation (lack of gene flow between groups) is the dividing factor. It results in the branching of the phylogenetic tree. Through its effect upon inbreeding, isolation also establishes and perpetuates gene patterns—a process of prime importance inasmuch as functional characters are usually the result of gene combinations rather than the effects of single genes.

It seems probable that cultural isolation analogous to the reproductive isolation within and between species of organisms has an important bearing upon social evolution. Social isolation has not been explored sufficiently to give us an adequate understanding of its role.

Complete reproductive isolation in organic evolution separates species, but also there exist numerous types of partial isolation that separate portions of species populations to some degree, and this partial isolation profoundly affects the characteristics, adjustments, and survival of the intraspecies groups.

Humans are one species. There is not only gene flow between all human groups with quantitative variations in its extent and rate, but there is also a horizontal diffusion (spatial) and vertical flow (temporal) of ideas, concepts, and symbols with variations in the degree and rate of flow.

Complete or partial isolation probably has a highly important effect upon diversity and upon fixation of patterns in both organic and cultural evolution. Diversity and fixation allow whole integrated systems to be selected as units. Partial isolation enables parts of the system to have a particular effect upon other parts.

In human society, there is partial isolation between geographical groups, between language groups, between racial groups, between national groups, between religious groups, between professional groups, and between economic groups, to mention a few. There is also partial isolation between repeated unit institutions within these social groups, for example, churches of the same denomination, universities, and business firms in the same business.

Accompanying the numerous partial isolations, there is communication between all groups and subgroups within the species, so that there is a degree of coordinated unity for human society as a whole

that even transcends the lines of conflict in war areas.

It is obvious that one individual may belong to a number of partially isolated social organizations. On a much simpler level, there are parallels to this situation in the biological world. For example, a worker honeybee may sequentially take part in various hive activities and field work. A single human individual may have different social relations and serve different functions in each organization in which he is included. Each of the cultural units to which he belongs tends to develop balance and coordination in time. Progressive social evolution is in part dependent upon partial isolation. Either extreme isolation or extreme interchange would slow adaptive evolution, if it be granted that the biological analogies are applicable to social evolution. Individuals in their multiple group relations exert a control over both extremes.

The fluctuating degrees of isolation and interchange may themselves become homeostatic. As has been stated, homeostasis is not complete and static equilibrium. If disequilibrium has a function, and it often does, homeostasis may result from the maintenance and control of periodic fluctuations.

The guiding factor in organic evolution is natural selection. The unfit are eliminated and the fit perpetuate their fitness. Genes established in different pattern combinations are sorted by natural selection with resulting increase in adaptation and homeostasis. Survival of the fittest carries connotations of competition. Although competition has a strong effect upon survival, the unfit may be eliminated and the fit may survive even in the absence of competition. Of course the fit may be a more inclusive group system than the individual unit part. Cooperation rather than conflict may enhance fitness, and survival may be quantitative rather than qualitative. Selection may choose any partially independent unit for survival. It may determine the future existence of a gene and the elimination of a slightly modified mutation of the same gene within the same chromosome, cell, organ, individual, or population system. Selection may also choose large inclusive population systems for survival as wholes. Much confusion in the discussions of both biological and social evolution stems from a misunderstanding of this fact.

Other biological mechanisms leading to adaptive evolution have been postulated but it now seems safe to say, in spite of continued controversy, that the only theory that adequately explains the origin of complex adaptation is the theory of natural selection. Experiments as well as multiple observations have validated this principle.²³

It appears that selection is also the guiding force in social adaptation. The effects are strictly analogous because selection operates on genetic variation in organic evolution, whereas it operates on cultural variation in social evolution. If, however, the analogy between genes and symbols has some validity, the analogy between forms of selection may have significance. It is admitted that there are intricacies in the analogy between natural and social selection that need investigation and clarification. Kroeber¹⁷ states that cultural change is additive and accumulative, whereas organic evolution is substitutive. Substitution and accumulation occur in both types of evolution, although the processes may differ in degree.

It would seem probable that social evolution has moved toward increased adjustment and homeostasis by means of a sort of natural selection of more efficient systems and the slow elimination of the less efficient. The economic principle of *laissez faire* results in a selective sorting through success and failure.

Natural selection has not just favored the strong, the powerful, and the courageous. It has led to adaptations in innumerable directions, including both competitive and cooperative interrelations. Cooperation within the organism and within the intraspecies population often increases efficiency and well being and is therefore subject to positive selective pressures. This seems to be the real reason for the evolutionary trend toward better physiological and behavioristic integration—mainly physiological within the organism and mainly behavioristic within the population system. By means of cooperation, the group may become more powerful in its competition with other groups and species. But individual power may be self-defeating if it is harmful to the group. Power, therefore, does not always lead to survival. If power is used to augment the long-term well-being of the species as a whole, then an evolutionary trend toward an increase in power may be expected. The relation of strength and power to survival is often misunderstood. Whether or not the strong survive depends upon the use made of strength. Nietzsche built an ethics upon his belief in an evolutionary trend toward increased power, a trend that modern biology refutes.⁸

Selection operates on whole units as well as parts, so whole populations may be selected as entities. Social units are doubtless subject to selection in their entirety without precluding a relatively independent selection of the component individuals. The species as a whole is often the integrated unit. Selection will favor mechanisms that increase living efficiency among individuals composing the species

and that increase the adaptation of the entire species in its environment. Fitness may be internal or external adaptation or both. Mortality may result from a lack of relative fitness, but often a differential reproductive rate results without the early death of the individual. This recognition of death or prevention of reproduction as necessary to much progressive evolution is disturbing to some. Certainly there is no biological evidence to indicate that the prolongation of individual life is a general directional trend in organic evolution. The individual life span may be increased in time if greater species efficiency results. But evolution will lead to a shorter individual life span if the species adaptation is thereby increased. With the increase of the individual life span in recent human history, social science must direct much study to this problem. Because of the time involved in learning and productivity resulting from education, a long individual life is probably highly important to progressive social evolution. However, the relative pliability of young adults compared to the aged suggests that there may be an optimum of age proportions in a progressive society.

Elimination of the unfit does not always involve death. For instance, competition between males for a female may prevent one male from fathering offspring at least temporarily, but usually does not result in his death. There are many other cases that show that competitive elimination is not always lethal to the loser, and it should be emphasized that cooperative units with less extreme competition may survive at the expense of less cooperative systems and interactions.

When we view survival, differential reproduction, and elimination as guiding factors in social evolution, we immediately see that death is relative.¹⁸ Business enterprises often succeed or fail in relation to their relative efficiency in meeting human wants, but the life or death of the individuals composing the business firm is not crucial. Symbols and ideas may survive within a culture without complete dependence upon the life or death of the individual originating or harboring the concepts. Erroneous ideas may be replaced by correct ideas in the maturation of the individual personality. This principle seems to be grossly misunderstood under some forms of government. Witness the political purges in Soviet Russia, the murder of millions of Jews by the Nazis, and the numerous executions of "heretics" under the Spanish Inquisition.

The degree of automaticity of progress is a problem. It is true that progress toward increased homeostasis in organic evolution is almost wholly the automatic result of natural selection, but the

growth of the learning capacity in man, his conceptual thought, and his ability to transmit symbols have produced a striking change in the processes of evolutionary progress. The social growth of knowledge of the physical, biological, and social environment enables man to control the processes of change to a marked degree. Conscious selection has taken the place of natural selection in the rapid evolution of domestic animals and plants. There would seem to be no doubt that man controls his own biological and social evolution to some extent, and many social trends are the result of his intelligent choice of alternatives rather than the result of automatic sorting by means of natural selection.

With the growth of a scientific understanding of the causes and effects of social evolution, man can exercise greater control over his own destiny. The evolutionary trends resulting from unintelligent and unconscious processes may never be eliminated altogether, but there can be little doubt that far more rapid progress toward better adjustment will be fostered by conscious understanding and control. The general direction of progress toward homeostasis is the same in the long run, whether the selective sorting be natural or conscious, but the relative speed of evolution is vastly different. Control, of course, does not imply force by a dictator or dictatorial clique, often with false concepts. Control is by broad social understanding and skill made possible by individual freedom of inquiry and speech.

The analytical task of the social scientist is tremendous. It is usually difficult to isolate and evaluate the factors leading to social progress or decay. The biologist and psychologist have shown that multiple factors may be analyzed in part, and a partial understanding is far better than no understanding, although there are accompanying hazards. Many phenomena are now partially understood and controlled that were formerly considered beyond the capacity of human intelligence. Historically, defeatist philosophies were constantly invoked in the attempt to prevent scientific advance, for example, the philosophy of vitalism that sometimes assumed that inorganic principles could not be applied to life. Prevalent at present is a philosophy that states that biological principles cannot be applied to social and humanistic man.

To return to the analysis of selection, we find that it varies in its effects with certain environmental periodicities. There is a tendency for selection temporarily to guide a system toward short-term efficiency, but the long-term efficiency ultimately prevails because the systemic unit possesses long temporal dimensions. A gene that increases ad-

adjustment to a warm climate and that decreases adjustment to a cold climate is positively selected during the summer and is negatively selected during the winter. There are doubtless many instances of fluctuating selection pressures in social evolution also. An individual German could not get a certain job in the late 1930's unless he were a Nazi. But, in the late 1940's, an individual could not get the same job if he had been a Nazi.

In both biological and social systems these fluctuating pressures balance each other or result in compromise solutions. On occasion internal fluctuations may match environmental periodicities, for example, seasonal behavior. On other occasions, asymmetries and lack of equilibrium may be functional and a homeostatic maintenance of controlled variables may evolve, for example, the accumulation of emergency food in one place.

Because both the organism and the social supra-organism are temporal entities incorporating the past and exhibiting adaptation to that portion of the future that repeats the past, selection operates on temporal adjustments, and long-term adjustments tend to survive over short-term adjustments, even though the short-term efficiencies may be temporarily greater. Predators and parasites are known under certain circumstances to destroy their potentially permanent food supply by over-exploitation. Strikes for higher wages beyond the capacity of the balanced economy of the business sometimes destroy the livelihood of the workers.

There is a prevalent attitude among biologists that competition and cooperation are opposites and that one prevents the other.²⁶ Actually there is a fair amount of biological evidence that indicates optimal values of competition, too much or too little both being detrimental to the survival of the group. The studies by Allee⁸ on the social hierarchies show that competitive interaction results in a cooperative organization under some circumstances. It seems plausible that competition among men may be socially beneficial at optimal pressures and that either too much or too little competition might interfere with the growth of cooperative social organizations. In the biological world, there is evidence that competitive pressures have survival value and that evolution has resulted in optimal competition. In contrast to competition, the function of cooperation in attaining increased homeostasis is much more obvious, although neither biologists nor social scientists have fully explored the role of competition in its relation to cooperation.

Cause and effect are not always linear in time and much confusion results from the assumption that they are. It can be demonstrated with data

from the study of organic evolution that variation, isolation, and selection are not linear in the time sequence of their actions. Genetic variation has often been assumed necessarily to precede the action of selection. But there is much evidence that the mechanisms of variation have a function, and that these are consequently selected and evolve in an adaptive direction. The mechanisms of isolation may also have survival value. These factorial complexes have circular and web relations and the effects often influence the continuous or repeated cause. Many problems of teleology are resolved by an understanding of circular causation. Feedback mechanisms are examples of circular causation. We sometimes find that the end becomes a means.

The principle of circular causation is certainly applicable to the factors determining social evolution. The conscious control of the events of social evolution made possible by scientific knowledge is a clear example. It is quite possible for an individual who is the result of a process to influence the future operations of the process and its effects.

Correlative Effects in Organic and Culture Evolution

If organic and human social evolution are even partially proceeding according to similar forces and principles, one might expect to find certain parallels in the results. It has already been mentioned that the dividing factor in organic evolution is reproductive isolation. The branching of the family (phylogenetic) tree defines systematic or taxonomic groups in biology. We also see that separations of subgroups result from partial rather than complete isolation. We certainly find partial cultural isolation dividing social systems and there is no doubt that evolutionary "trees" may be drawn for numerous social and cultural patterns, for example, the splitting of languages from a common stem and the evolution and branching of styles of art.

We are also aware of horizontal infiltration or diffusion in addition to vertical origins in time, for example, the French words incorporated into the English language following the Norman conquest. Horizontal diffusion of genetic components (gene flow) occurs among subspecies and racial groups in organic evolution, always with partial isolation separating the groups. Horizontal diffusion of species is also characteristic of the evolution of interspecies community systems discussed later. Horizontal diffusion is more complicated in social evolution than in organic evolution. Social "evolutionary trees" show numerous intertwinings of the branches. Childe¹⁹ has thought that cultural evolution is

sharply separated from organic evolution by this phenomenon. It is true that there is a quantitative difference, but there is no qualitative distinction on this basis.

As natural selection operates upon different organisms in a similar habitat, convergent evolution may lead to similar analogous adaptations. These have similar functions but different origins and detailed mechanisms, for example, the wings of birds and insects.

In social evolution, symbols may be similar in function but unrelated directly in origin. Media of exchange and economic value (money in the broad sense) originated independently at numerous times and places. Taboos on incest have originated independently in widely separated cultures. The cultural anthropologist has given us many other cases of convergence of social practices and customs, including many details of ethical patterns.¹⁷

An adaptation may often become modified so as to perform several successive functions in turn during progressive evolution. In later stages a more recent function may dominate or replace an earlier function. For example, among the vertebrates the support of the gills became modified into jaws and portions of the jaws later were incorporated into the middle ear. The function of a basically homologous organ changed from breathing to eating and ultimately to hearing. Changes of function can be traced through numerous social lines. Words often change their meanings in time. Architectural form may change from utilitarian to esthetic value. Religious ritual may symbolize one concept at an early time and a different concept in modern times. Individual aggressive hostility that has survival value at an early evolutionary stage may be channelized to serve a cooperative social function in a later evolutionary stage.

Former adaptations may be lost, but the genes involved in the growth of an organ may be so woven into the fabric of the system as to be lost with difficulty. We may detect thousands of vestigial and functionless structures in the bodies of organisms. Examples are the vestigial eyes of cave fishes, the pelvic bones of whales, the reduced wings of flightless birds, and the ear muscles of man. It is a simple matter to find such vestiges in our cultural patterns. Examples are functionless details of architecture and sleeve buttons on men's suits. Legal codes are notorious for their inclusion of outmoded laws. The spelling of a word frequently outlives its original phonetic value. Religious ritual often repeats a form, the meaning of which is lost in antiquity.

Although the word degenerate is often used for regressed structures, the implication is not fully

justified. There is always a compensation for the loss of function, often by incorporation into a more inclusive system where inefficient duplications of function are reduced. Although the reproductive function of a cell has regressed in a nerve cell, it is hardly correct to refer to a brain neuron as degenerate. All animals have regressed as they lost the power of photosynthesis possessed by their plant ancestors, but are all animals thus degenerate? It would seem better to recognize regressive evolution as a concomitant of adaptive specialization or division of labor in more inclusive systems, and to measure the resultant increase in homeostasis of the whole system. We must be careful to evaluate the complexities of social regressions before we label them degenerations. We must also realize that an evolution toward simpler organization at one level of integration is usually if not always associated with an evolution toward efficiency and complexity of organization in a more inclusive level.

Applications of Biology to Ethics

If ethics is correctly conceived as a learned integrated cultural system symbolizing human experience of success and failure in striving for a better life, if ethics is a set of customs pertaining to responsibility, duty, and right, and if right is conceived as conduct leading toward increased optimal living and homeostatic control, we may now study its application to special problems. Garvin³ says that the proof of a connection between evolution and morality will establish no new moral system as such. However, the scientific relationship of biological and cultural operations and trends gives us a more refined comparative basis for evaluation and produces a more universal standard for ethical judgment. A basic classification of ethics is proposed as it relates to the integration of various levels of organization.

Individual Integration. Evolution has been guided by means of natural selection toward individual integration. Most individual integration is physiological in its nature because of protoplasmic contiguity. However, particularly with man, instinct, learning, and conscious thought also integrate the individual personality, and ethics may function at the individual level, particularly from the "internalization" of social experience. Other things being equal, any controlled behavior that leads toward individual disintegration may be considered unethical, and any behavior leading toward personal balance, control, and greater effectiveness may be considered ethical. Overindulgence in narcotics or alcohol, for instance, might be considered unethical at the personal level. In contrast, any behavior aimed at per-

sonal integrity would increase individual homeostasis and would be considered ethical. Effectiveness through self-discipline, serenity through appreciation of the arts, health through exercise and diet, individual expression through creativity, all these are ethical. One may say that each person is morally responsible and dutifully bound to strive toward individual health, emotional balance, and personal integrity and effectiveness. Or, to put it in somewhat different words, an individual with these attitudes has been and will be favored by selection. Flügel²⁰ and J. S. Huxley²¹ discuss the ontogeny of the moral personality, particularly from the standpoint of psychoanalysis. Individual psychology is highly important to any general theory of ethics.²⁹

In terms of evolutionary science, we may say that adjustments leading toward individual homeostasis were selected because of their influence upon survival. Before the advent of symbolic thought, these mechanisms of homeostasis were essentially genetic. But with the emergence of intelligent man, symbolic systems could lead effectively toward the same goal with a greater degree of plasticity under diverse environmental and social conditions. Society usually enhances individual homeostasis. So concepts of right and wrong enabled man to control his behavior more effectively for optimal living. Individual happiness is often given as the goal of human life, but homeostasis seems to be a more adequate goal for both organic and social evolution, and has the added advantage of being subject to objective analysis, quantification, and comparison. Possibly individual happiness and individual homeostasis are correlated, but the two concepts are difficult to compare by scientific method. Individual homeostasis of plants, animals, and man can be compared, but individual happiness of man is almost impossible to compare with that of, say, an amoeba or an ant. Spencer, T. H. Huxley, Haeckel, and in general Darwin, emphasized individual egoism as an ultimate principle of biological conduct. Simpson⁴ emphasized the ethics of personal responsibility and knowledge. At present we should not either underemphasize or overemphasize the individual as an integrative unit. If the homeostasis of the individual comes in conflict with the homeostasis of the group, adjustment will evolve either toward the more important function or toward a balanced compromise of the conflict. The evolution of adaptation within the individual organism supplies numerous convincing examples of compromised adjustment between conflicting optima. Perfection of adaptation to different optimal conditions of existence is never attained and cannot be considered attainable.

It is not implied in the forgoing statements that an individual can always control his actions. Although alcoholism is unethical if the individual has the power to direct his own behavior, the addict may be sick rather than morally undisciplined. The same may be said for neurotic and psychotic behavior. In a broad sense, there may be no more blame for a person who has a psychotic disturbance than if he has a bacterial disease. Any individual or social action leading to a cure of such a disease is ethical. Condemnation on so-called moral principles may be unethical if it is based upon a false understanding of the causes, and if it does not lead to amelioration, cure, or prevention.

Sexual Integration. The integration and mutual adaptation of the sex pair was an early biological evolution based upon physiological and behavior mechanisms. Sex is one of the most obvious examples of population differentiation with division of labor and integration, both leading to increased homeostasis of variation by means of recombination. Many other family and social functions emerged from the sex relationship. In the case of sex it should be noted that homeostatic control over genetic variation was established through selection, thus illustrating circular causation. In later stages of evolution the sexual differentiation of individuals itself became genetic.

Much of human psychology and social life is an outgrowth of sex biology, and it is to be expected that ethics and morality will evolve to a marked degree around the sexual relationship. Marriage has become a sacrament of the church and morals have guided the mores and stability of the marriage relationship.

The sexual pair is a biological entity and it is likewise a social entity. Any custom that integrates husband and wife and increases their adjustment and homeostasis is ethical. Any self-controlled behavior that disrupts the biological, emotional, esthetic, and social values of marriage is unethical. An infinity of detail is ordered by this fundamental principle that is surely biological in its foundation. Biological trends are repeated in the social manifestations of human sexual relations.

Family Integration. The family unit, like sex, is a socially integrated group with an obvious biological basis. Adaptation between parents and offspring has evolved with an increased control over shelter, food, and defense of the offspring. Specialized organs such as mammary glands have undergone adaptive evolution. The unit of selection is the family group as a whole including its temporal dimensions. The possession of efficient mammary glands does not give survival value to the individual

mother, but it does give survival value to the family group. Behavior leading to parental hazards and sacrifices evolved among animals long before the rise of human ethics.

Again we find a behavior system evolving out of a physiological system that integrates the group. Some of the group behavior is genetic, as can also be demonstrated in sexual behavior; but with the human family much of the behavior is learned, intelligent, and transmitted through symbols. The emerging learned behavior tends to evolve in the same direction as did the inherited behavior, namely, toward maintenance of the family unit and more optimal conditions for the development and survival of the young.

Behavior leading toward human familial homeostasis has usually been considered ethical, and our analysis substantiates this conclusion. Behavior leading to a disruption of family ties, especially during the period with dependent children, is considered unethical. We may also note that parental interference with the establishment of sexual and family relations by mature children is often considered unethical even though the parental control may have been ethical during the formative years. In other words, ethical relations between parents and offspring change as the children mature.

Social Integration. Animal societies are real biological entities established by evolutionary factors. Like other biological units, they exhibit a division of labor, integration, and a directional evolution toward increased social homeostasis.^{10, 28} Among insects the social interrelations are largely the result of hereditary initiation of social behavior that may be modified by physiological and ecological factors. In the human species the social interrelations are largely developed from learned behavior and symbolic communication. It is true that human society is an analogue of insect society. The two types of social behavior have had independent origins, have very different social mechanisms, and have no common social ancestry.¹⁶ Primitive social behavior among the primates may possibly be homologous with human social behavior, but the subhuman social behavior of primates hardly transcends the levels of sexual and familial integration. Among the insects, several social systems have arisen independently and are analogous. For instance, the highly organized society of the ants is analogous to the remarkably equivalent society of the termites. The ant society evolved from the family system of the nonsocial wasps, and the termite society evolved from the family system of the nonsocial cockroaches.

Most of the attitudes and behavior that we term

ethical involve human social relations, and we shall return to this subject shortly.

Interspecies Integration. We often find, in the study of organic evolution, that groups of species, each reproductively isolated from the other and often very distantly related, exhibit mutual adaptation to each other. The integration of interspecies systems without genetic continuity between the species can best be explained through the action of natural selection upon the interspecies system.²²

Although genetic continuity integrates the individual, the sex pair, the family, and the intraspecies society, only environmental or ecological continuity, particularly by means of natural selection in similar habitats, integrates the interspecies groups. We have seen, however, that the mechanisms of integration include both internal and external continuities in intraspecies systems, so that supraorganismic coordination may still appear in interspecies systems as the result of natural selection, even with the loss of genetic continuity among the interadapted species. Obviously the organism, the intraspecies supraorganism, and the interspecies supraorganism are analogues. These systems have significant similarities produced by the action of similar forces, and they all show division of labor, integration, and an evolutionary increase in homeostasis. Although quantitative comparisons of the degree of integration are lacking, it seems safe to conclude that the individual organism is likely to be a more tightly knit system than the population group, and that the intraspecies population usually shows a greater degree of integration than the interspecies system. In other words, internal adaptation and homeostasis of the whole unit decreases in the more inclusive systems. There is probably a greater degree of internal control within the cell than within the multicellular organism, and there is a greater degree of social control within a society than within the ecological community, but each unit lives in a more optimal environment as it evolves in association with other units, and this optimal environment is often enhanced or produced by the evolving organism or supraorganism.

Certain physical and biotic environments are more favorable for life than others, so that competition for limited necessities is greater in some habitats than in others. The more favorable habitat is the one in which the organism or group system may attain a greater degree of internal homeostasis without adjustment to extreme fluctuations of many physical and biotic factors. Orientation to and movement toward favorable environmental con-

ditions are evolutionary adaptations. Adaptations evolve that maintain ecological position in favorable habitats, either through attachment devices or through movement with moving factors.²³ Organisms also may avoid severe competition by evolving adaptations to or control over somewhat unfavorable habitats. Adapted organisms already occupying a favorable habitat will prevent poorly adapted competitors from moving in, although vacant habitats may be populated by initially poorly adapted species. Optimal physical conditions often are incompatible with optimal biotic conditions and varied compromises result. Both exoadaptation to the physical and biotic environment, and endoadaptation within the organismic system show evolutionary trends toward increased homeostasis. What often appears to be a regressive evolution with decrease of homeostasis in an individual may be shown to be an increase of the homeostasis of the ecosystem which incorporates the physical habitat with its associated organisms. Many more exact data are needed before this general trend can be said to be convincingly demonstrated, but the hypothesis is challenging and some evidence indicates its validity.

Without question no species of animal or plant has had such a profound effect upon the physical world and its life as has social man. Homeostasis has not only developed within the society of man but man has also learned to some degree to control his external environment, including all other living organisms. His rapid development of power over the world, however, has sometimes resulted in harm to himself or succeeding generations and, when it does, negative selection occurs. Julian Huxley²¹ gives his opinion that important organic evolution has ceased as social evolution has attained dominance. It is the author's opinion that the evolution of interspecies integration and of homeostasis of the ecosystem will involve both important social and organic evolution, undoubtedly partly under intelligent control by man. Clark²⁴ emphasizes that "the economic life of early man can most fruitfully be considered in relation to the wider economy of nature."

If man, like other organized living systems, is moving toward increased homeostasis, and this control of optimal values involves other forms of life upon which man is dependent, it seems clear that ethical behavior must include his relations to his domesticated animals and plants, and also to the wild animals and plants occupying his global habitat. We must remember also that the interspecies community, like other biological systems, has time

dimensions. The human species is part of a larger entity that is temporally integrated.

Let us ask ourselves whether there is any scientific justification for a human individual to make a personal sacrifice to save African elephants or California redwoods from destruction, particularly if these living organisms are separated from his individual use either geographically or chronologically. The answer seems clear. Man is integrated with his own species the world over. He is also integrated with other species the world over. And he is integrated with both past and future generations. The human individual is part of a temporal supra-organism that serves him and which he serves in mutual cooperation toward more optimal self-regulation for his own benefit and for the benefit of others included within the same system.

We are already aware of the harm that may be done through the short-sighted destruction of water resources, soils, forests, and wild life, with consequent decrease in the optimal conditions of life. And what we do not know far transcends our present knowledge. One of the greatest values man can attain is a true knowledge of the intricacies of himself and his social, biological, and physical environment. The destruction of complex coordinated systems before they can be studied and evaluated is a great handicap to the increase of knowledge and ultimate control.

It may thus be stated, on the basis of some objective evidence and known principles, that man has an ethical responsibility toward the animals and plants of the entire earth as well as toward contemporary and future humanity. Intelligent conservation of our wild life and natural resources is ethically sound. Wasteful exploitation and destruction is wrong and bad. Even harmful species may be studied with benefit to mankind so that a far-sighted ethics may suggest the preservation as well as the control of harmful species. It is advisable that we base our advancing interspecies ethics upon sound scientific information of the physical and biological world in which we live and upon which we are dependent. Besides their economic value, fishing and hunting have recreational value, but conservation policies should not be dominated alone by the desires of the sportsman.

Ethics and Social Homeostasis

Let us now return for a somewhat more extended discussion of one of our main themes—the biological basis of social ethics.

Races are partial genetic segregates within the species of man. The majority of species of animals

and plants have similar subdivisions resulting from partial reproductive isolation and natural selection operating in different habitats. Sometimes, although not always, races and subspecies diverge until they are reproductively isolated and temporarily genetically discontinuous. They evolve into full species by this process. In the case of the human species, the development of transportation has reversed the trend toward increasing isolation of the races, so that we are now witnessing the slow breakdown of ethnic barriers. The human species is already a genetic and cultural unit and the present indications point to increasing integration and coordination of all peoples. Ethical relations may be expected to change with changes in the organization of the system. Ethical relations between species and between races of the same species have different qualities because of obvious differences in the type of group unity.

Under natural conditions, competitive relations between species that overlap in ranges are often great, and drastic elimination may occur with the survival of one of the competing species. In other cases, the competing species may occupy somewhat different ecological niches and an evolution of balanced exploitation, toleration, or interdependence may occur with both species surviving. On occasion species may evolve cooperative relations and become mutually interdependent.

Although competition occurs between individuals within a species, it is noteworthy that combat and drastic elimination are more common between species. The reason for this difference is that the individual is in a greater mutually beneficial relation to other individuals of his species group than to other species, and natural selection operates for the benefit of the whole species rather than only for the benefit of the individual. It is therefore usually against the long-term interests of society for an individual to kill or harm another of his own species, although it may be to the interests of both the individual and his species population to kill an individual of another species. Also, individual exploitation of other individuals within the same species is harmful to the group and will be negatively selected, whereas cooperation, integration, division of labor, and balanced compromise usually result in an increase of efficient homeostasis for all concerned and will be positively selected.

Therefore we find that the concept of the "brotherhood" of all mankind rests upon firm biological principles. Ethics leading to firmer integration and mutual benefit between races of man is in conformity to biological trends. Behavior leading toward racial elimination, racial exploitation,

and human slavery (including the antebellum variety, economic slavery during the early stages of the Industrial Revolution, and politico-economic slavery as reported in Russia at the present time) does not lead toward increased long-term homeostasis. The exploiter is harmed along with the exploited, and natural selection of these cultural characteristics gradually tends to eliminate unethical racial practices. Behavior close to that of many stated principles of Christian ethics would seem likely to survive the onslaught of temporarily powerful philosophies like that of Nazism with its false theory of racism.

We can pick cases of unethical racial relations close to contemporary America. All of us are aware of the tendencies to suppress, subjugate, and humiliate certain Negroes who are striving to take their dignified place in the great advance of civilization. Good ethics would appear to be that which integrates the Negro with advances in education, the arts, the sciences, and general social progress, and allows him opportunity to be creative. Bad ethics is any action depriving the Negro of human rights and opportunities. The Negro also has a moral responsibility to make his proportionate contribution to social progress.

International conflict and war are probably the most conspicuous wastes of human energy and wealth in the contemporary world. When the world was less integrated, before modern transportation and communication existed, relatively isolated cultures arose with their local qualities of homeostasis. These comparatively independent cultures were often fairly well adjusted to their immediate conditions. All of these separated cultures in different stages of social evolution are now thrown together. Interdependence has rapidly advanced, but conflict has also increased. Attempts at aggressive dominance and exploitation of nation by nation breed resentment, hatred, and defense.

Viewing national warfare from the point of view of biological trends over millions of years, one might predict an ultimate social evolution beyond this stage of national conflict toward a world order of mutually cooperative relations among nations. Division of labor and specialization between cultural groups seem entirely compatible with the biological principles already discussed. Each group could contribute its unique values to the common social welfare. There is no trend toward uniformity of function within organized biological systems, and there seems to be no reason to fear that all provincial customs and artistic accomplishments will be lost in the future world order.

It is not possible to predict with certitude that a social evolution away from national conflicts and devastating war will occur within a decade or so. It may take many centuries to achieve. In the meantime it may be necessary to operate on the cancers in the body politic that seem to rise and flourish temporarily, to the detriment of both the diseased and the healthy parts of the human supraorganism. At present there is too little social science that diagnoses social disease and discovers cures. More often emotionalism leads the minds of men toward inadequate or misdirected action against social ills. Prejudice and bias combined with ignorance often guide social action. A sort of natural selection gradually suppresses harmful customs and fosters better mores and ethics. It is expected that social science with a broad perspective from humanistic and scientific knowledge will increasingly dominate human social behavior and international relations.²⁹

The observer of modern management-labor relations is often struck by the apparent inefficiency of the system. Reacting to the exploitation by the owner class during the early decades of the Industrial Revolution, labor has developed defenses and attained power. Sometimes the use of power by labor is detrimental to labor itself. Labor and management often seem to be unaware that they are together united in an interdependent relationship, that cooperation between them contributes to a larger society upon which they depend and which they serve. If labor and management were to cooperate in order to exploit the society to which they belong, decreased homeostasis would occur. So progress demands an ethics of mutually beneficial relations between labor and management in industry, and it also demands mutuality between industry and the general public. Communism with its false theory of antagonistic social classes would seem to be doomed in time.

Any increase in selfish exploitation of society by any individual or any group is ethically bad. And any increase in homeostasis through cooperation among all classes of human society is ethically good. On the basis of the selection of efficient practices leading toward optimal control over the necessities of civilized life, we may confidently predict a gradual increase in cooperation between specialists grouped into social classes.

Balanced relations and optimal conditions for social advancement are practically infinite in number. Great gaps in exact knowledge are now apparent and much research is needed in the fields of the humanities and the sciences. Efficient function depends not only upon the accessibility of materials and the organization of operations, but also upon

the size of the group performing the function, and the spacing of the functional units may also have optimal values. A repetition of functional systems occurs within more inclusive systems, and social institutions exhibit such duplications in an analogous manner to the organ and tissue replications in individual organisms. Both a degree of competition and a degree of cooperation between parts with similar functions exist, and an evolution toward proper spacing and balance may be anticipated. The control of the size of populations and sub-populations would better adjust the individual to his environment and to his social economy. Much needs to be learned about populations in their relation to natural resources and food supply. Surely a mature and modern ethics will encourage mores that better living conditions, rather than produce the starvation, misery, poverty, and human degradation that accompanies overpopulation. Quantity of life is not necessarily the same as homeostasis of life.

Social institutions, whether they be different churches, different schools, or different business firms, often seem to view their relations as wholly competitive. An evolutionary perspective upon their social functions, their integration, and their relationship to the more inclusive societal system may bring a better understanding of their role. And with this better understanding, better ethical standards may bring about a healthier relationship. What is often termed good business may be found to be ethically bad, particularly when the selfish profit motive runs counter to the beneficial service to society.

When a benefit is gained through cooperation by means of learned behavior, honesty enhances confidence between the cooperating individuals, whether the social unit be the sex pair, the family, or the social system. Honesty is thus ethical, because it tends to establish firmer cooperation between individuals, between business firms, or between nations. Dishonesty tends to be destructive of group homeostasis and is consequently unethical. Lying and cheating in international diplomacy, in business transactions, or in games tend to destroy the mutual trust necessary for the attainment of mutual welfare.

Justice, when contemplated from the viewpoint of social evolution, emphasizes individual responsibility to the social system, establishes criteria for the judgment of human conflict, and enhances attitudes of fairness and compromise in human relations. Law based upon justice augments social homeostasis. It can be seen also that social progress necessitates functional pliability and change in legal codes.

Several recent authors have come close to recognizing the evolutionary role of homeostasis. Those who emphasize the functional role in existing individual and group systems have not analyzed the concept from the modern standpoint of the dynamics of evolution.^{7, 13-15, 29} Some have a narrow concept of homeostasis.²⁵ Some have not fully recognized the reciprocal relations between the individual and the group systems.⁴ Some have over-emphasized the differences between the mechanisms of organic and social evolution and have under-emphasized the functional analogues.^{4, 21, 26} Some have not fully bridged the gap between biology and human society.^{10, 23} Many have not adequately compared human society to biological systems.^{5, 12, 19} Some have not adequately related individual human psychology and social behavior. Many fail to relate conflict and competition to tolerance and cooperation.²⁶ No one has adequately related human social homeostasis to ecological homeostasis. No one has adequately analyzed the relation of individual and social homeostasis to the esthetic arts. Because of the large number of facets to the whole problem, together with the limitations of scientific knowledge available to any individual scientist, much further analysis and synthesis of pertinent data remain to be done.

Many statements made in the body of this paper are over-simplifications. The simplification for brevity and clarity may sound dogmatic and categorical. No generalization is more valid than the data substantiating it. Detailed information does not embarrass sound generalization and theory. It is the "life blood" of scientific interpretation. Thousands of investigators working for centuries are needed before some of the hypotheses stated here can be either refuted or adequately verified. At the present time we can draw only tentative conclusions based upon indicated correlations. We are still a long distance from the attainment of an adequate knowledge and understanding of social man. In the meantime, however, we have an indicated order of social and biological events upon which we can build.

We can now begin to perceive the direction we should follow in our search for ethical truth, ethical wisdom, and methods of increasing human welfare. Not knowing why social evolution has taken place nor whither it is bound, but vaguely sensing its reality and direction, man has often rationalized his intuition by means of mystical explanations. At present we are only at the threshold of a science of social evolution—a science that can objectively analyze changes in esthetics, ethics, economics, and politics, and thereby increase our ability to inter-

pret, predict, and evaluate processes and effects more adequately than is now possible.

Progress equated with increased homeostasis of living systems organized in various levels of integration seems to be a general trend of biological and human individual and group evolution. This does not mean that fluctuations of trends, delay, disintegration, and extinction never occur. The cause and effect web relations of intricate life activities and attributes are clarified and a general directional trend can be detected, measured, and compared in ordered systems that have both unique differences and common similarities. The trend does not lead to a final arrival at perfection. It also fails to solve the ultimate question of what part evolutionary progress plays in cosmic evolution and increased entropy. It would seem that all life on earth would cease with the dissipation of the energy of the sun and what atomic energy is available to complex chemical organisms. The standards for moral evaluation emerging from scientific knowledge of organic and social processes are relative and never absolute nor final, but a refinement of ethical decision is available through increased knowledge of natural and social events and processes. All problems are not completely solved because knowledge is never complete, but many questions that heretofore have seemed unsolvable,²⁷ now can be partially resolved and can contribute to the welfare of humanity.

The scientific principle of homeostasis assists in the resolution of many controversies and dilemmas. It relates the individual to the group, divergence to convergence, competition to cooperation, isolation to integration, independence to dependence, conflict to harmony, life to death, regression to progress, conservatism to creativity, organic evolution to social evolution, psychology to biology, emotion to intelligence, the conscious to the unconscious, science to ethics and esthetics, reality to value, and means to ends. It is both a mechanism and a trend of life processes. It indicates the gaps in our knowledge and understanding, and it directs future investigations.

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- Energy in the Future*. Palmer Cosslett Putnam. New York: Van Nostrand, 1953. 556 pp. Illus. + tables. \$12.50.
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Philippine Fish Culture

WALLACE E. MCINTYRE

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THROUGHOUT monsoon Asia, fish culture in ponds, rice paddies, and shallow bays occupies a prominent part of the land utilization pattern. In general, it is most important in the heavily populated areas of very intensive population pressure. Thus in China, Japan, and Indonesia, fish products are grown in conjunction or alternation with the regular crop mainstays. However, fish culture is by no means a universal practice throughout southeast Asia, even in areas well suited to such a crop, and for this reason the development and improvement of fish culture represents a significant addition to the food resources of many of its regions.

Since 1902, population of the Philippines has grown from about 7,000,000 to 20,000,000. This increase, plus the traditional emphasis on production of export agricultural products, has brought about a marked pressure upon the food resources of the islands. With a rice and fish national diet, the Philippines finds itself in the predicament of being a rice and fish importer. Since World War II, an average of 21,365,000 kilograms of fish products valued at P24,920,000 has been imported yearly.* Estimates of the Institute of Nutrition of the Philippines place the normal per capita consumption of fish at 25.55 kilograms of fish annually; this makes the fish needs of the country approximately 511,000,000 kilograms. Of this amount, only 296,000,000 kilograms were produced by the entire Philippine fish industry in 1951.¹ Yet the islands contain 600,000 hectares of swamp land plus extensive tide flats, lagoons, and shallow harbors and bays, many of which are good sites for fish culture projects. If all the unutilized waters could be used in fish production, a sufficient supply of protein food could undoubtedly be obtained for the entire population. It is toward this goal that the Bureau of Fisheries

*A kilogram is 2.2 pounds. A peso is approximately \$0.50 in U.S. currency.

and other government agencies of the Philippines have been working, by establishing model fish culture centers, introducing new fish types, training fishermen, financing fish pond construction, leasing public lands, carrying out research in fishery problems, and similar activities (Fig. 1).

Brackish Water Culture

In the Philippines, only estuarine waters are used for fish culture. Saltwater swamp lands are utilized for pond rearing of the bangos or milk fish; shallow bays and inlets serve as sites for oyster farming. The Philippine Bureau of Fisheries estimates that estuarine waters are two to five times more productive per unit area than agricultural land. Since 1946, a rush in leasing government owned brackish and estuarine areas has taken place as interest has grown in fishpond culture (Fig. 2).

Bangos Fishponds

Although the remains of primitive fishponds indicate that cultivation of bangos is an old industry in the Philippines, it is only recently that research and modern technics have been applied to show the true possibilities of fish culture. At the present, bangos culture has reached such a stage of industrialization that three separate phases or operations have developed in some areas. Catching and handling of the fry has become an established industry, while, to a lesser extent, rearing the fry to a fingerling stage has been separated from the production of marketable fish.

Bangos Fry Industry

Although acclimated to brackish and even freshwater under artificial conditions, the bangos is a natural inhabitant of the open sea and will not reproduce except in its native saltwater. Depending on the locality, the fry season lasts from March to August with a peak in May and June. The fry are

caught in many areas, such as Balayan and Batangas Bays, and along the sandy coasts and river mouths in Mindoro, Marinduque, Samar, Leyte, eastern Luzon, Zambales, Oriental Negros, southern Panay, and others. Tiny and almost transparent needle-like fry are caught in abaca cloth push nets and a variety of seines and traps. They are then placed in earthen jars with fresh seawater, about 2000 to 3300 fry each.²

The bangos fry are caught by fisherman employed by concessionaires who obtain the rights to municipally owned fishing grounds. Fisherman are paid for their catch according to the quantity as determined by a sampling system. In turn, the fry are sold at the beach to representatives of fishpond operators, and the unsold surplus is taken to Manila by train, truck, and airplane. Fishpond operators near Manila Bay then may obtain the fry from wholesale depots at the International Airport, the Tutuban Railroad Station, and near the Divisoria Market.³

Bangos Nurseries

Although the practice of raising the fry to market size in a continuous operation still is common, certain fishpond owners limit their activities to raising fry only to the fingerling stage. In turn, the fingerlings are sold to other fishpond owners who continue the process to the marketable stage.



FIG. 1. Experimental ponds, Dagatdagatan Saltwater Fishery Experimental Station. By experimenting with fish-raising techniques and providing a "show window," the Bureau of Fisheries encourages private development of fishponds.

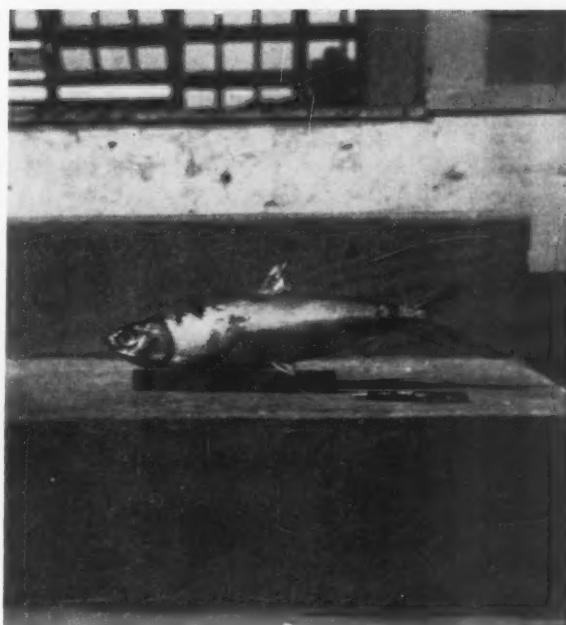


FIG. 2. The bangos or milk fish is the only fish produced in Philippine fishponds in important numbers. In three to six months, bangos attain a marketable size of 1 to 1½ pounds.

Nursery ponds for fingerling production range in size from 500 to 5000 square meters, separated into units by low partition dikes with inlet and drainage pipes. Prior to stocking, the ponds are drained and leveled, after which a series of flooding, draining, and drying activities is carried out in order to rid the pond of predators. For operating conditions, the pond depth is maintained at a depth of three to five centimeters in order to prevent the growth of filamentous algae, while encouraging the growth of lab lab, the food of the young bangos. Lab lab consists of a large assemblage of microscopic plants and animals closely associated with the bottom soil. It develops at the pond floor in a greenish, brownish, or yellowish mat or scum.

When the pond is covered with lab lab, it is stocked with an average of 30 to 50 fry per square meter (300,000–500,000 per hectare). Nursery pond water remains quite salty, receiving only occasional changing with new tidal water. During a hard rain, the water level is raised to prevent a rapid change in salinity and temperature. In time, the supply of lab lab becomes exhausted, necessitating artificial feeding. When this happens, rice bran is broadcast over the ponds twice a day at the rate of 5 to 12 kilograms per hectare.

After 1½ to 2 months, the fingerlings are 5 to 10 centimeters long, and may be sold to rearing pond owners. By controlling the food supply, how-

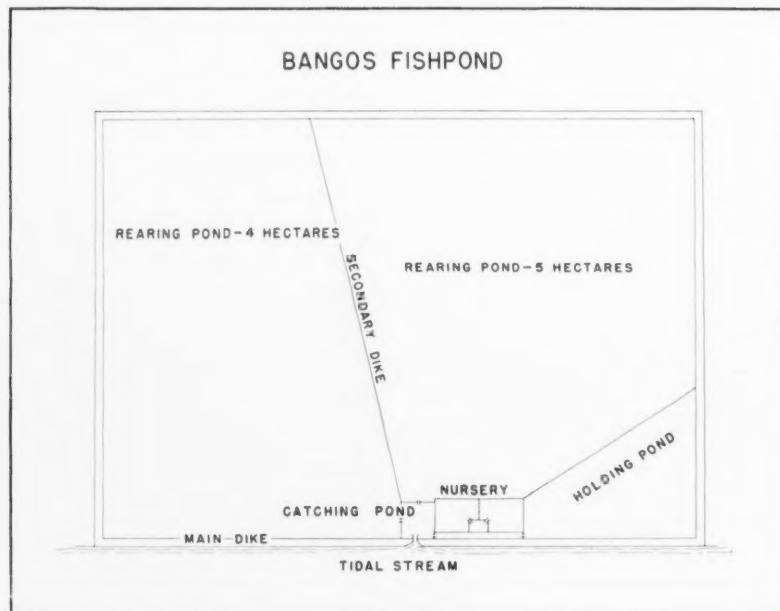


FIG. 3. Model layout for a 10-hectare bangos fishpond project (Bureau of Fisheries, Manila).

ever, the fish may be stunted at this stage for one to two years, thus maintaining a supply of fingerlings throughout the year. Despite the fact that bangos spawn but once annually, multiple cropping in the fishponds is feasible.

Owners of big fishpond holdings, which may be as much as a thousand hectares, cannot raise enough fingerlings, and conversely, small owners do not al-

ways find it convenient to do so. It is these people who supply the major market for the nurseries.

Bangos Rearing Ponds

Good rearing pond systems include three compartments: the catching pond, the holding pond, and the rearing pond (Fig. 3). The catching pond is a small subdivision 10 to 30 meters on each side, located near the main gate. As do many other fish, the bangos tend to swim against a current; so, by admitting water to the pond, the fish can be concentrated in the catching pond for harvesting (Fig. 4).

Fingerlings are kept for some time in the holding pond which is a transition device. The food provided in the deeper water of the rearing pond is filamentous algae (lumut). A stay in the holding pond helps the fish in this change of diet from lab lab to lumut, and also enables them to grow a bit larger and thereby to be more capable of withstanding enemies in the big ponds.

Finally, the rearing ponds are stocked with 1000 to 1500 fingerlings per hectare, and from then on the fish need little attention.⁴ The water goes stale eventually, but since it is stocked, it cannot be changed completely. The pond is merely freshened by admitting water through the main gate during high tide and allowing it to escape during low tide. When the food is exhausted, algae from outside sources are planted, and certain types of seaweed are added as substitute food. Artificial fertilization is difficult because of the changing of water, so pond fallowing, temporary cultivation with rice, or dry



FIG. 4. A catching-pond compartment. When water flows through the gates, fish swim against the current and are concentrated for catching with nets. This often is used for catching young fish or partial harvesting.

season solar salt production are locally resorted to in order to improve and maintain productivity. In some cases, vegetation is cut and placed in the ponds for fertilizer, but nowhere in the Philippines is found such use of commercial fertilizers as takes place in bangos ponds in Formosa (Figs. 5 and 6).⁵

Depending upon the food available, bangos reach a marketable size, about 1½ pounds, in three to six months. With the development of the fingerling industry, so that fingerlings may be ordered throughout the year, and the use of substitutes for algae as food, two to four crops of fish may be produced each year. Each crop should amount to at least 1500 pounds per hectare, and would far exceed the expected return per hectare of rice. In many cases, however, bangos are sold too soon. The



FIG. 5. Rearing ponds. The tidal marshes of Manila Bay north of Manila have the largest area of fish culture development in the Philippines.

farmer may be in need of cash, or a religious holiday may provide a tempting market. As the fish can be caught at will, they are brought to the market in a fresh state (Fig. 7).

Concomitantly with the bangos, giant shrimp fry also are placed in the ponds. Shrimp and other fish often enter during the freshening activities, to add further to pond production. Some crustacean pests which bore holes in the dikes are also edible.

Fish Pond Development

From 1946 to 1951, the area in fishponds increased from 53,032 to 84,769 hectares, with a corresponding increase of catch from 16,100,000 to 29,669,150 kilograms, or about 10 percent of the



FIG. 6. Filamentous algae largely cover a newly readied rearing pond. The algae provide food for the fish and are often consumed completely so that supplemental seaweed and algae must be added.

total Philippine catch of 296,089,602 kilograms. Of the 602,183 hectares of undeveloped swamplands, 415,470 are brackish water swamps.⁶ In order to overcome the high cost of initial development, which is estimated at P12,000 for a 10-hectare unit,



FIG. 7. Mature bangos escape into feeder canals and are salvaged by seining. This technic is also used on partially drained rearing ponds when complete harvesting is desired.

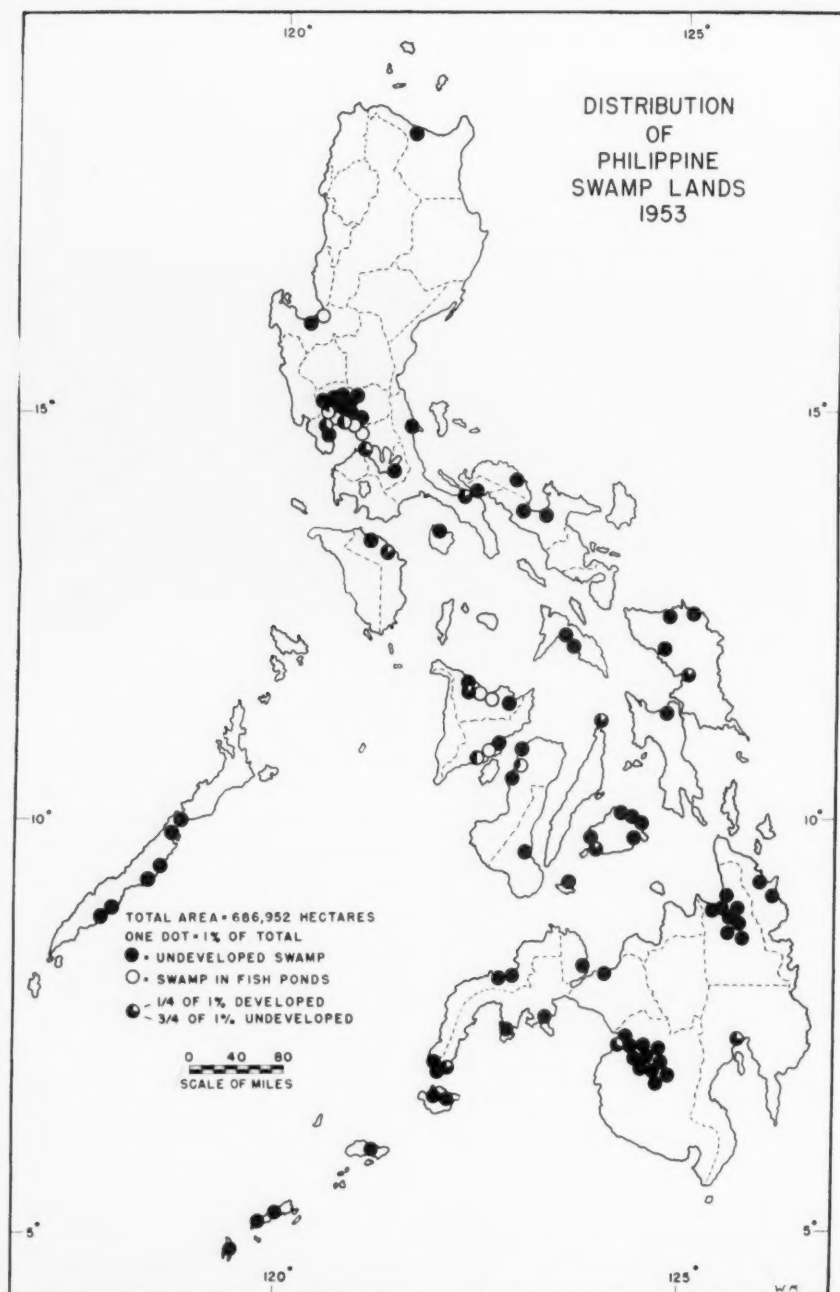


FIG. 8. Distribution of brackish and freshwater swamps of the Philippines. Major fishpond development is in the provinces of Bulacan and Pampanga north of Manila, and on Panay Island (Roxas City and Iloilo.) Source of statistics: Bureau of Fisheries, Manila.

the Philippine Government, through the Reconstruction Finance Corporation, has established a system of financing pond construction and improvement. This program encourages the development of areas not exceeding 25 hectares by advancing 80 percent of the expenses involved. As a result, the estimated annual net profit of P2200 per 10-hectare

pond has aroused increasing interest in the bangos industry (Fig. 8).⁷

Freshwater Fish Culture

Despite the abundance of freshwater swamps, artificial reservoirs, irrigation canals, and paddy fields, no freshwater pond cultivation of any im-

portance takes place in the Philippines. Farmers catch dalag, the interesting air-breathing fish, in rice paddies. Several other native fish are caught and trapped in paddies, ditches, and streams, but none of this is planned fish culture. Yet in many areas of Indonesia and southeast Asia, freshwater fish are cultivated in large numbers in rice paddies, dooryard ponds, and reservoirs, and in Thailand, even in wooden boxes. Freshwater fish culture not only provides a convenient source of protein and increases productivity of the land, but it also overcomes the lack of transportation and refrigerating facilities which contribute to the expense and scarcity of fish in inland areas. Philippine freshwater natural fisheries have been so destructively exploited and exhausted that pond culture of freshwater species looms even more significantly as a future source of protein.

In order to encourage freshwater fish culture, the Bureau of Fisheries has introduced several proven species, such as the gouramy from Indonesia and the plasalit and tilapia from Thailand. Demonstration fish ponds have been constructed, literature has been made available to the public, and fry of gouramy, plasalit, and tilapia have been raised and distributed.

Oyster Culture

Shellfish culture in natural brackish and estuarine waters, not considering fish ponds, represents another potential source of protein. At the present,



FIG. 9. Bamboo stakes with old oyster valves or tin cans impaled upon the stakes to serve as spat collectors are common sights in the estuaries and lagoons of Manila Bay.



FIG. 10. Oyster farms of Bacoar Bay between Manila and Cavite. On the left, horizontal poles are threaded with cultch. On the right, wires holding cultch hang vertically. The mass of poles has increased silting to a serious degree.

only a small amount of oysters and kapis (window-pane shells) is produced by farming technics, although oysters are as common as ordinary fish in many coastal areas of the Philippines.

Oysters are found in tidal rivers, creeks, salt marshes, and landlocked bays where the bottom is, ordinarily, semi-sandy, hard, and sticky. For many years, small plots of oysters have been cultivated at Bacoar Bay (southeastern Manila Bay), in tidal streams and lagoons just north and south of Manila, and in several other points along the western and northern coast of Luzon. The most promising sites are Northern Luzon, Lingayen Gulf, Manila Bay, Batangas Bay, the coasts of Tayabas and Sorsogon, the regions around Catbalogan in Samar, northern Leyte, and the coasts of Negros and Palawan. Bacoar Bay in Cavite contains about 200 hectares of privately owned oyster farms, while 10,000 hectares await development in Lingayen Gulf.

In the Bacoar Bay-Manila region, the oyster rearing areas do not provide the firm bottom most suited to oysters, and are commonly mud-choked shallows rapidly filling with silt. In order to prevent smothering of the oysters, and also to utilize the water vertically, several types of hanging methods of culture were copied from Japan, and the tray method from Australia. The first method used, and one commonly observed in the more sheltered tidal streams and lagoons, is the stake or

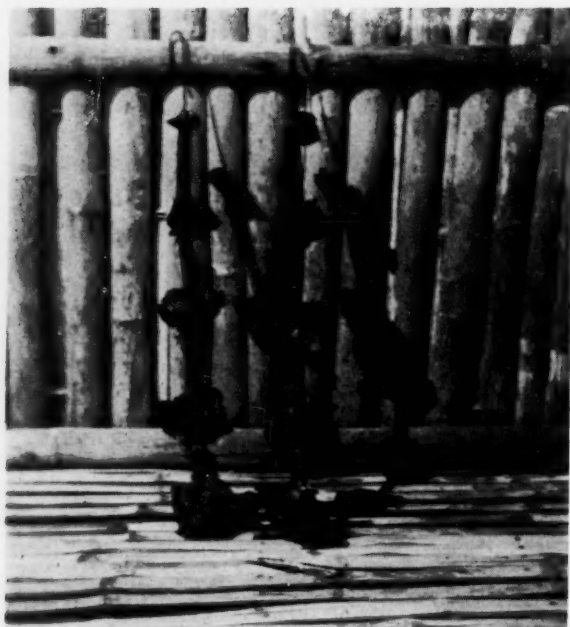


FIG. 11. Oysters growing on wires used in the hanging or bitin method. The hook at the top hangs over a horizontal pole at the surface. Oysters are kept out of the mud and utilize the entire depth of water.

tulus method. In this case, bamboo stakes are driven into the mud, with old oyster valves or tin cans impaled upon the stakes to serve as spat collectors (Fig. 9). In less protected or larger areas, sturdy bamboo posts are driven into the bottom as supports for long horizontal bamboo poles which are placed at levels within the tide range. For the hanging or bitin method, wires with a crook on one end are hung vertically from the horizontal poles. Old valves are threaded on the wires as cultch, thus enabling the growing oysters to live above the muddy bottom and to use efficiently the available space. In many shallow areas, a variation of this method is used, whereby long slender poles threaded with cultch are suspended horizontally between the bamboo posts. Usually four 20-meter "long lines" are spaced about eight inches apart on a frame. This is known as the line or sampayan method. The tray or screen method consists of placing cultch on chicken wire or bamboo screening which is built in the form of movable trays. These are easy to move from place to place and are convenient for fattening marketable oysters, or for improving undersized oysters collected from stake or hanging methods (Figs. 10 and 11).

In more remote coastal areas, several more primitive techics are used locally. Bamboo logs are staked to the bottom at the margin of tidal creeks so that oyster spats may attach themselves to the bamboo.

Where big stones and coral rocks are available, the stones (paringit) are arranged in suitable areas along the shores of a cove. Oyster spats eventually attach to the rocks.

The Bacoar Bay oyster farms on the southeast shore of Manila Bay were originally established as a government demonstration farm. So many private individuals have installed similar facilities that the bay is littered with poles and stakes as far as one can see. In fact, the increased sedimentation resulting from the submerged forest of bamboo poles is at present threatening the life of the entire industry.

No attempt has been made to obtain statistics on oyster production in the Philippines. Many are produced only for subsistence. There is surprisingly little demand for them on the market. The lack of ice and adequate transportation is undoubtedly a handicap which presumably can be overcome in time if the market justifies it.⁸

Kapis

An interesting product usually associated with regular oyster farming is the windowpane shell, known in the Tagalog dialect as "kapis," although commonly misspelled "capis." The windowpane shell is a pearl oyster, *Placuna placenta*, whose entire shell, including the meat, is about one centimeter in thickness, whereas the average short diameter of large shells is about 12 to 14 centimeters. Because the right valve is flat, it is more valuable than the slightly convex left valve.

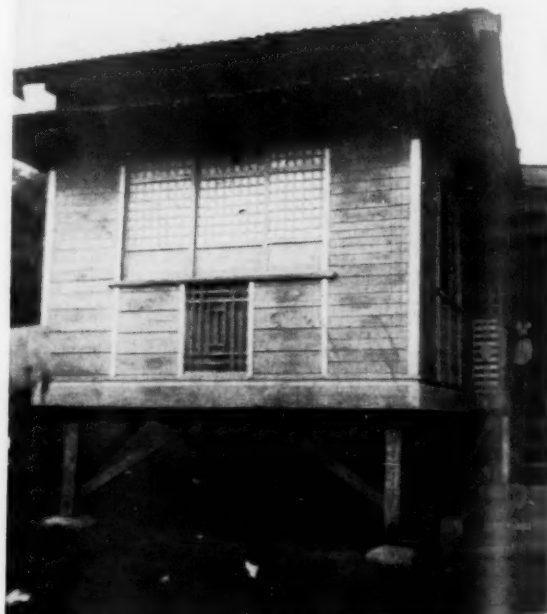


FIG. 12. Windowpanes made from kapis shells. Large homes of the well-to-do also utilize kapis for a distinctive window material.

Although widely distributed throughout the Philippines, the more important kapis beds are located along eastern Manila Bay, Pangolas and Talibon in Bohol, Valladolid, Occidental Negros, Roxas City and Iloilo in Panay, Lingayen Gulf, and many localities in Mindanao. Favorable natural environments seem to be beds of grayish or bluish mud in the tidal zones of estuaries, coves, or bays, and conditions favorable to oysters are also favorable to kapis. However, the shell is free and unattached, and sometimes it is thickly covered with mud and debris.

Utilizing the extensive low tide flats of Bacoar, Bay, the Philippine Bureau of Fisheries operates an experimental and demonstration oyster and kapis farm near the village of Binakayan, Cavite, which has served to arouse interest on the part of private oyster farmers in the Manila Bay area. During November and December, kapis seedlings 25 to 40 millimeters long are gathered by fishermen along the sandy shores of Manila Bay and are sold to kapis farmers for ₱2.00 to ₱2.50 per 10,000 pieces. Seedlings are planted in favorable areas which are surrounded by protective fences of bamboo brushes and sticks. Often the fences are used simultaneously as cultch for oysters. When planted in November, the kapis may be harvested the following June.

After the kapis are harvested, the meat is removed and the shells are soaked in water to clean them and to produce a characteristic luster. First grade shells sell for ₱90 per 10,000 pieces, and the fourth grade shells (usually the curved left valve) for about ₱40. In 1949, 15,947 kilograms valued at ₱10,530 were exported.

For a hundred years, kapis shells have been characteristically utilized as windowpanes throughout the Philippines. This is especially true for the sliding type of window that is closed only at night or in inclement weather. Tiny translucent pieces about 3 inches square are set in many rows within large frames to form these unique and distinctive windows (Fig. 12). Many novelties are manufactured from the shells for native as well as for tourist consumption. Although rather infinitesimal, the meat is considered to be a delicacy and is used in a variety of native dishes such as chowder, kapis omelet, and adobo.⁹

The new Philippine Republic is beset with many problems as a result of its change from a colonial to an independent status. One paramount problem is the need for greater self-sufficiency in food, a need fostered by a rapidly growing population, a desire to industrialize, the necessity to conserve dollar reserves, the impending loss of the country's former position within U.S. tariff boundaries, and the long-established agricultural and cultural patterns that need modification.

In view of this very practical problem, the presence of large areas of undeveloped or poorly developed swamplands and shallow coastal areas provides a most promising possibility for overcoming the present serious shortage of protein foods. The scientific production of bangos and oysters in brackish and saltwater sites, plus the development of freshwater fish culture in inland swamps, paddy areas, reservoirs, and irrigation systems can conceivably provide a sufficient amount of protein in itself, to serve the needs of the entire nation. Fish from backyards and farms is a reality in much of southeast Asia, and should be a reality in the Philippines.

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The Scientific Measurement of Fitness for Self-Government

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Dr. Dodd is research professor of sociology and director of the Washington Public Opinion Laboratory, University of Washington. He received his B.S., M.A., and Ph.D. from Princeton University and was a National Research Fellow at London University 1926-27. Dr. Dodd served in the U.S. Army during World War II as director of surveys, and as consultant with the Psychological Warfare Branch, Allied Force Headquarters, Sicily.

WHEN is a dependent people fit for self-government or independence? The mandate system and now the trusteeship system are intended to give a dependency either self-government or independence in the course of time, increasingly because of the fitness of the dependency and decreasingly because of international power politics or imperial interests of the controlling power. To carry out this policy of democratic concern for the welfare of the inhabitants requires that fitness be so specified that the inhabitants know what efforts or achievements by them will result in specified advances toward full self-government. There is need for a procedure to make this transition from dependence to independence a pacific and constructive one and to provide an alternative to the appeal to force that was the sole resource of the dependency in the past. If fitness can be defined and measured and degrees of it set as goals, the trusteeship system is likely to work with less friction and probability of bloodshed in the future.

The Facts to Date

The officially declared purpose in the United Nations Charter and Trusteeship Agreements that the dependency shall be developed toward eventual self-government or independence has taken cognizance of this problem and suggested its solution. The outlook for its solution is made more hopeful by the increased willingness, occasionally evident in the modern world, of some nations under certain circumstances to give up their dependencies and sincerely work toward developing them, not for exploitation, but for the welfare of the inhabitants.

The first step toward the achievement of self-government for dependencies is to set up criteria

for measuring their fitness. We analyzed¹ this question to find the criteria that had been agreed upon by both the dependency and the controlling power in the cases of the Philippines, India, and Iraq. There resulted agreement on some eleven criteria, five dealing with internal affairs and six with international obligations of the dependency. These criteria included such requirements as the ability of the dependency to maintain (a) its civil government, (b) its territorial integrity, (c) its financial solvency, (d) a competent judiciary, and (e) a public opinion wanting self-government; and to guarantee the rights of foreigners and minorities and other international obligations of debts, treaties, and so forth, legally contracted. These criteria thus analyzed were the identical set that were later adopted by the Mandates Commission of the League of Nations. This official declaration of the criteria of fitness for independence is the first step in working toward a solution of the problem of peaceful transition from dependency to self-government.

The analysis was materially aided by techniques developed by the social sciences in the last decade or two for measuring such complex and qualitative phenomena. From these facts a scheme for furthering self-government peacefully may be developed—which is the purpose of this paper.

A Proposed Measuring Instrument for Self-Government

(a) *How to measure the criteria for self-government.* The instrument here described for measuring fitness for self-government is based on several assumptions which it is well to state clearly at the start. It assumes that: (1) self-government is often a desired goal; (2) measuring fitness can be a use-

ful step toward self-government; (3) this step can reduce conflicts; and (4) fitness can be measured by suitable statistical indices. This paper is mostly concerned with giving evidence in support of the last assumption—that fitness can be measured.

Before describing the indices for measuring fitness a review of the theory of measurement on which they are based may be useful for political scientists.

Our theory of measurement,* which is applicable to any social phenomena and is not limited to dependencies nor even to governmental phenomena, may be described in three cycles: the qualitative, the quantitative, and the correlative.

For the qualitative cycle, one begins by naming classes of phenomena and their subclasses in a classification scheme. A subclassification may be carried to as many levels or degrees of fineness as may be needed.

For the quantitative cycle one begins by observing whether a given qualitative class is present or absent in a particular situation. This makes it an all-or-none variable which may be assigned the numerical values of one or zero and then may be weighted later as desired in combining with the other variables. Wherever possible such all-or-none variables should be observed more exactly in an ordinal series, or ranks, such as in stating whether there is none, some, more, or most of that variable in a given situation. This ordinal variable in turn should be still more exactly observed wherever possible by converting it to a cardinal variable which is a multiple of equal and standardized units. Ordinal variables are designated "first, second, third . . .," while cardinal variables are designated "one, two, three, . . ." When the cardinal variable has been calibrated, that is, when its limits, reliability, validity, and so on, have themselves been measured, it becomes the most exact type of variable and is the ideal in the quantitative cycle.

For the correlative cycle the indices of the quantitative cycle, whether all-or-none, ordinal or cardinal, have all their intercorrelations calculated by appropriate technics. This determines the structure or pattern of the indices or classes of phenomena that are involved in the total situation under study. In proportion as the determinant of the table of intercorrelations vanishes, the system of observed variables can be considered a closed system, since any one variable within it can be completely pre-

dicted from the other variables, that is, its multiple correlation with the others is unity. This serves to measure how completely or adequately, for the predictive function of science, the variables in the situation have been observed.

Now apply this theory of measurement which, in its broad outlines, can be shown to subsume all measurement that exists in any science, to the problem of measuring fitness for self-government. The eleven criteria adopted by the Mandates Commission were subclassified through seven levels into a resulting 350 subclasses, or items, of objectively observable phenomena (Table 1). These 350 items were then converted into quantitative indices by observing them either as present or absent or present in ordinal degrees or present in cardinal amounts. Consider, for example, three sample indices at these stages of precision. These three indices measure, for instance, the three major internal criteria of a competent judiciary, a favorable public opinion, and financial solvency.

For a qualitative index converted into an all-or-

TABLE 1

FIFTEEN ILLUSTRATIVE TYPES OF INDICES SELECTED FROM THE SET OF 350 SUCH ITEMS*

- I. Civil Government (indices 1 to 135)
 5. Personnel Administration
 - (b) Classification
 - 33 Is there a uniform job classification?
 - 34 To what percentage of the civil servants is it applicable?
 - 35 Are the standards of admission to each category defined?
 - 36 Are salary scales for each category established?
 - 37 Are they actually applied?
 8. Health and Sanitation
 - (a) Health Work
 - 71 What is the total score on the "Appraisal Form for City (and Rural) Health Work"? (Adapted from the American Public Health Association's scale)
 - (b) Personnel
 - 72 What are the per capita numbers of doctors, of nurses, of midwives, of sanitary inspectors, of pharmacists?
- II. Military
 2. Military Power
 - (a) Personnel
 - 141 What is the per capita number of military personnel?
 - 142 What is the percentage of native personnel (senior officers; line officers; junior officers; staff officers)?

* This dimensional theory of measurement and the other statistical technics in this paper are more fully developed in the author's *Dimensions of Society* (Macmillan, 1942, 944 pp.) and *Systematic Social Science* (Department of Sociology, University of Washington, Seattle, 1947, 785 pp.), a typescript volume offset for criticism and revision before full publication.

* These items were developed by Felicia Fedorovicz in a thesis under the author's direction. Copies of this provisional scale may be obtained from the author.

TABLE 1 (continued)

III. Order and Security		
1. (b) Public opinion on security		
161 How many times in the last month have you heard of a . . . (each crime below in turn) . . . in this community (village, tribe, etc.)		
	% hearing in sample	Mean number of rumored crimes
Theft	_____	_____
Cattle theft	_____	_____
Burglary	_____	_____
Rape	_____	_____
Murder	_____	_____
etc.		
IV. Financing		
4. International Obligations		
196 What is the proportion of per capita foreign debts to per capita yearly national income?		
V. Judiciary		
1. Impartiality		
201 Are there any special privileges for religious, racial, economic, or other groups?		
202 Are there any foreign concessions?		
203 Are the court fees reasonable or are the costs prohibitive for the poor?		
VI. Public Opinion		
3. Political maturity		
(a) Activities		
281 What percentage of the electorate voted in the last national election? Municipal election?		

none quantitative index, consider the criterion that the dependency must possess a judiciary commanding the confidence of the people. Alongside the courts of the controlling power, let parallel native courts be set up with alternative jurisdiction as formerly was the case in various Near Eastern states. Let the native courts try those cases where both litigants agreed to take their case there. At the end of each year, the percentage of all the cases in the court that went to their own native courts could be calculated and judges appointed for the next period, such that the native judges would be that percentage of all the judges. Thus, as people gained or lost confidence in their native courts, the percentage of native judges in the country would increase or decrease. When they attained full confidence in their own judiciary, all judges would automatically become nationals; and the dependency would have achieved complete control of its judiciary by demonstrated confidence in it. The action of taking the case to the native court is a qualitative item of behavior. Coupled with its absence, the not-taking-the-case-to-a-native-court becomes an all-or-none item of behavior. The arithmetic mean of such items is the percentage of cases taken to the national court. (Every percentage is the arithmetic mean of an all-or-none frequency variable.)

For an illustration of an ordinal variable, consider a public opinion poll determining the criterion that there shall be a predominant public opinion in favor of self-government or independence. Here, instead of asking the question, "Do you approve or disapprove?" the question could be asked more exactly in ordinal degrees specifying the degree of self-government that is favored or as the degree of intensity of approval or disapproval of self-government. Of course, such a question should be carefully phrased in alternative forms, penetratingly analyzed by supplementary questioning to make sure that the opinion expressed on the question at issue is adequately reflected in all its complications and is independent of the particular phrasing of the question. The questions should elicit the "give/get" ratios or price of independence which the citizens are willing to pay. This cost of what they want can be measured in eight types of indices that we have developed.² Thus indices of willingness to pay higher taxes, have military service, and put up with possible specified degrees of lowered efficiency in government services, can gauge the strength of the public opinion in terms of what the people will give for what they want to get.

For a third illustration, this time a cardinal variable, the financial solvency of the budget can be determined in cardinal units of money.

For the correlative cycle, the 350 indices need to be combined in successive stages until eventually they yield a single index or scale of total fitness. This combination is usually made additively with some kind of weights. Ideally, the weights should be regression weights determined by multiple correlation, which is calculated by correlating the indices against some accepted measure of dependence-independence such as the difference between a set of dependent areas and another comparable set of independent areas. As a first approximation, these weights may be secured as ratings by a panel of competent specialists.

For this weighting, a decimal system has been developed that distributes 100 points among the subclasses of each class wherever it may fall in the hierarchy of classification which breaks "fitness" down into subclasses and sub-subclasses in successive levels. The number of percentage points given to each subclass is according to the judge's estimate of its relative importance among the other subclasses of its class in contributing toward fitness for self-government. In this way the weights of all the subclasses of any one class add up to 100. Provision may be made for an extra unidentified subclass in the event the judges feel that the given specified subclasses are an inadequate analysis of their class.

The weight assigned by the judges to the unidentified class measures the degrees of inadequacy of the other subclasses. With this decimal weighting system, the net weight of any class, anywhere in the hierarchy on any of the seven levels, toward total fitness is simply the product of its percentage and the percentage of all classes above it in the hierarchy. This yields indices for every item or combination of items up to the total fitness so that the whole, as well as any of its parts, is measurable. This decimal weighting system is flexible in permitting the insertion or removal of any items above or below it, with consequent shift of weighting only in the subclasses.

It remains to be seen whether the ratings would transcend the raters, that is, to what extent the ratings assigned by different panels of judges with different ideologies would differ from each other or give a constant result. Thus, in constructing attitude tests it has been found by Thurstone that panels of judges with very different attitudes themselves will yet agree on rating the meanings or scale positions of statements of attitude so that the attitude scales they construct transcend or are independent of the attitudes of the judges who constructed them. If it should be found that the ratings do not transcend the ideologies of the raters and that they yield significant differences, then the scale could still be applied but with specified weighting systems, for example, Communist weightings, Republican weightings, or a UN Trusteeship Council weightings system.

The reliability of this weighting system has been experimentally measured. Shannon³ secured weightings from social science faculty and student groups. He found no significant differences in mean weights when he subclassified his data into expert raters and inexpert raters. They correlated 0.9 together (± 0.008). The ratings differed significantly from chance, which would assign equal weights in every subclass in a class. On repeating the ratings, correlations of ratings of individuals between first and second ratings ran as low as 0.41, but correlations of the mean first ratings and the mean second ratings ran up to 0.997 (± 0.002). The split-half correlation of odd versus even items was 0.93 (± 0.006). These studies proved that the weights could be highly reliable if they are the mean weights of a panel of judges.

(b) *Reliability, validity, and norms.* The next steps still to be taken in constructing the scale of fitness are to determine its reliability, validity, and norms.

Reliability can be determined for one index of it as the correlation coefficient between one determi-

nation of the scale and a second determination of it on presumably the same phenomena, as when one set of a person's determination of the indices is correlated against another set's determination of the same indices.* To the extent that this correlation is high, say above 0.9, the scale is judged reliable; that is, it is free of errors of observation due to the observer. Many of the indices are fixed by censuses, school, tax, budget, and other statistics that would not vary much if reobserved. But other indices which are mean ratings by experts or polls of samples of the population might vary more on reobserving them. Hence their degree of reliability must be experimentally isolated and measured.

Validity is definable as the correlation coefficient between the scale and an accepted index of dependence-independence. How high does the scale, when applied to a group of independent and a group of comparable dependent areas, correlate with the all-or-none variable of independence or lack of it? The higher this correlation, the more valid the scale, that is, the more closely it is proved to measure what it claims to measure in society. At present the validity of only a few indices has been explored. Shannon⁴ has found correlation scattergrams with correlations in the 0.2 to 0.5 range between dependent or independent states as the one criterion variable to be predicted and illiteracy, gold reserves, and other factors as independent or predictor variables. These preliminary findings suggest that by multiple correlation technics a scale can be built and proven to measure more accurately the degree of independence.

For this purpose of determining the norms, a "para-nation technic" is proposed. It may be sketched here in oversimplified summary; eventually the Trusteeship Council might work out details. Let the degree of fitness demanded of a candidate dependency, in order for it to qualify for full self-government or independence, be some preassigned amount such as the average degree of fitness of ten para-nations, which are nations comparable in as many respects as possible to the candidate area. Let these nations be measured by the scale, and their arithmetic mean determined. Call this point "100 percent fitness" for the candidate nation (Table 2). This means that the dependencies must be more fit than the less competent independent nations of its class, yet need not measure up to the most competent, but only attain the average.

With this 100 percent point on the scale of fitness

* The more the two sets of observers represent different viewpoints or cultures, the more their degree of agreement will establish the objectivity or rerating reliability of the scale, of course.

determined for a given nation, subdivisions of it, when reached, could determine when that candidate would reach specified increments of autonomy. Thus, it could progress gradually toward self-government by peaceful, rational, and predetermined steps.

Application of the Measuring Instrument

(a) *Possible administration of testing.* In order to try out the extent to which a measuring instrument can contribute to the peaceful evolution of a dependency toward self-government, the instrument must be applied and developed further under field conditions. Administrators of dependent areas must become more interested in applying social science technics to their practical problems. It is to be expected that such interest will grow sporadically but may be encouraged by clear statement of the goal and available means. The goal here would be a controlled experiment for testing the hypothesis implied in the second and third assumption above.* This fitness scale hypothesis might be stated as: It is expected that in proportion (1) as a people's fitness for self-government is well measured; (2) increments in fitness are preannounced as the precondition for increments in self-government; and (3) increments in fitness are at least partly attainable by the people's own efforts then, self-government is likely to be achieved sooner, with less conflict, and with more satisfaction to most people, than without this measurement and motivation plan.

In order to test this hypothesis scientifically, controlled experiments would be designed, ideally, but in practice only crude approximations may be possible. These may be less crude, however, if the administrators have the plan of a controlled experiment in mind, even though they may lack the power to execute it cleanly. A controlled testing of the hypothesis implies finding two similar or matched dependencies. One of them would then have the aforementioned measurement and motivation plan applied to it while the other would not (or at least would get much less of it.) In a few decades the satisfactory and peaceful progress of the former toward self-government should be visibly greater than in the latter, if the hypothesis holds.

* The proposals here may seem a little naive to some political realists. The author recalls, however, proposing in Geneva in 1927 that criteria for terminating a mandate should be specified. Sir Austen Chamberlain replied that that was a job for the academic people before political administrators could move. The fact that when criteria were then worked out with a fellow academician (Professor Ritscher) these were the ones adopted by the Mandates Commission, gives hope that now in measuring these criteria the statesmen may again find the social scientists' technics useful.

(b) *Possible administrators of testing.* There are four types of authorities, each of whom could contribute a part to the full testing of the hypothesis. These authorities are the United Nations Trustees, national colonial offices, bureaus for research on government, and political scientists with statistical training.

(1) Trustees of United Nations trusteeships should be the first to apply the hypothesis and its implementing scale to their trustee lands. Thus a technic is offered that can help fulfill the official purpose of trusteeships—to prepare the trustee lands for self-government or independence. It offers a substitute for agitation, rebellion, and the appeal to force which have all too often in the past been the only course open to a dependent people wanting their freedom. It offers an evolutionary method of gradual growth toward self-government in place of revolution. It provides a definite constructive procedure which can motivate the inhabitants to those efforts and achievements that fit them best for taking over the management of their own affairs. In short, it offers a way to make the trustee's task easier. Of course, this fitness is not the only consideration in granting self-government or independence. Considerations of strategic defense and other self-interests of the trustee may still play a part, but the measuring and isolating of fitness removes the question of fitness from the realm of controversy and makes it less possible for any trustee to rationalize imperialistic policy by the claim that the trustee land is not yet fit for autonomy. Above all, the scheme would stimulate the development of fitness as a conscious, implemented goal.

This is a bit of the scientific method applied to administration, namely, the isolating of factors so that, with the causes and effects of each factor separately known, any one factor can be controlled even when other factors are still uncontrolled.

Trusteeships should begin this process of planned, peaceful transition to self-government by writing an article to this effect into the charters that set them up. The principle of measured and motivated fitting of oneself for self-government could be established by some such article as the following:

In order that the inhabitants may be constructively guided in their efforts to fit themselves for self-government by peaceful steps and without recourse to force, the Trusteeship Council shall advise and recommend to the Administrative Authorities as to the procedure for determining: the inhabitants' current degree of fitness for self-government, and what efforts or achievements by them, and what other conditions, are considered prerequisite to specified increments in self-government.

This method of scaling is also applicable to any department or function of government for which separate diagnosis and treatment may be wanted. Subscales for administrative, legislative, judicial, or party functioning, or any of their subfunctions, can be progressively developed by research. Bureaus

($x = 1$ para-nation)

With such ends in view, this paper is intended to do more than report on the construction of a scale of fitness for self-government. It is a general blueprint for further quantitative research in political science. It is an invitation to any political scientists to cooperative research in further developing the government scale and a more exact science of government.

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Magnetic Storms, Aurorae, Ionosphere and Zodiacal Light*

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Magnetic Storms

THE earth is a permanent magnet^{1,2} with a field at the surface of the earth distributed as if it were due to a magnetic dipole placed at the center of the earth. The magnetic lines of force are drawn in Fig. 1, each line being marked with the magnetic latitude at which it touches the surface of the earth. The field H is horizontal at the magnetic equator and vertical at the magnetic poles, the respective intensities being about 30,000 and 60,000 gamma (1 gamma = 10^{-5} gauss). By means of Gaussian harmonic analysis of the components of H observed at the surface, one may separate the portions which arise from magnetic sources below and above the surface. Early analyses indicated that about 2 per cent of H might be of external origin and of a type which would be produced by an eastward current ringing the earth of about 5×10^6 amperes and causing a horizontal field of about 600 gamma at the equator.³ A more recent analysis by Vestine¹ in 1947, using the latest and most complete magnetic data, reduced the portion of possible external origin to less than 1 per cent of H , that is, to less than about 300 gamma at the equator. Whether it was zero or some small value less than 1 per cent of H could not be established because of inaccuracy and incompleteness of magnetic surveys, particularly in polar regions.

Erratic variations or disturbances¹⁻³ of the terrestrial magnetic field occur which, although large when it is realized that they envelope the entire earth, rarely amount to more than 2 per cent of

the permanent magnetic field of the earth. They are rarely large enough to disturb a mariner's compass, but are easily recorded by the sensitive instruments of a magnetic observatory. The disturbances are in general so irregular as to defy complete classification, they may occur at any time, and they may be worldwide or local. The large disturbances are classed as storms; they are almost always worldwide and are usually accompanied by auroral displays. It is known from Gaussian harmonic analysis that the magnetic disturbances arise from electrical or magnetic influences which originate somewhere above the surface of the earth. And, primarily because there are more magnetic storms when there are more sunspots, it is believed that the storms are caused by emanations from the sun.

Of the large magnetic disturbances those with sudden commencements are recognized as a definite type. This type, which theories of magnetic storms have endeavored to explain, has several characteristic features. It begins simultaneously, within a minute, at all stations over the earth. In low latitudes its first effect is a relatively quick increase of the horizontal component of H , which may amount to 50 or 100 gamma in a few minutes or an hour. This is called the "first phase" of the storm.

The first phase is followed by a second worldwide feature, called the "second phase," or "major phase," in which the horizontal component of H usually falls in several hours to 100 gamma or more below its normal value, with many irregularities and oscillations, and may remain below normal for several hours or days. Finally, there is a recovery

* Based on an address of retiring chairman of Section B, at the AAAS meeting in Boston, December 28, 1953.

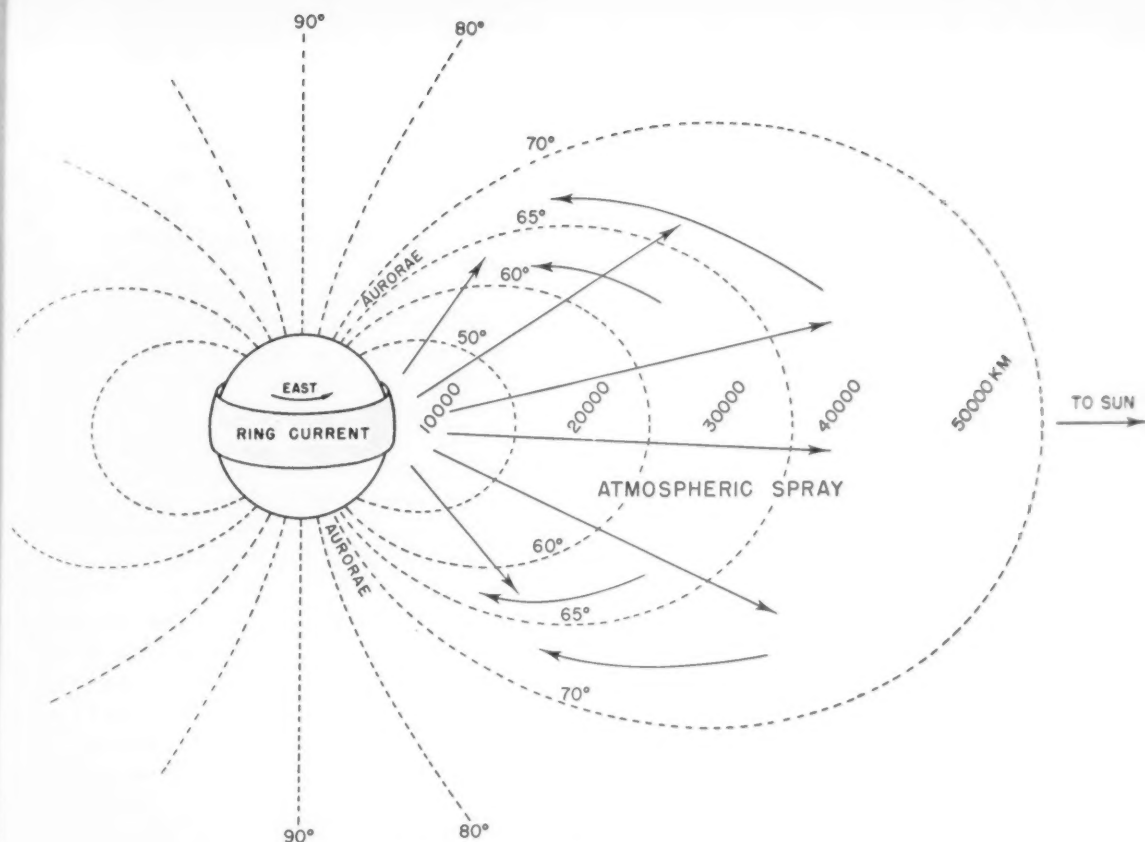


FIG. 1. Ultraviolet flare theory.

period. All the phases are not always well developed in all storms. There are storms in which the first phase is absent or hardly noticeable, and storms in which the first phase is not followed by a pronounced second phase. The first phase would be produced by an eastward electric current of the order of 10^6 amperes ringing the earth at the equator, and the second phase by a similar westward current. Various theories have assumed, or attempted to account for, the existence of such ring currents.

The worldwide phases thus far described are most intense at the lower latitudes and grow weaker toward the poles. In addition, there are other storm effects, superimposed on the phases, which are more intense in high magnetic latitudes than in low latitudes. These vary with the local time of the observing station, and are referred to as the "diurnal storm variations." These variations are complex and need not be described in detail here. Since the actual storm is composed of both the worldwide phases and the diurnal variations, the distribution with latitude of the magnetic energy of the storm, as measured at the surface of the earth, has a broad maximum in tropical

latitudes due to the worldwide phases, and maxima at about latitude 60° , north and south, due to the diurnal variations; there are shallow ill-defined minima around 30° to 50° , north and south.

Ultraviolet Light Theory

The ultraviolet light theory of magnetic storms and aurorae⁴ is described briefly first. Although its correctness is not established, it is instructive because it is the only theory which has attempted a unified explanation of magnetic storms and aurorae, and at the same time has brought into its compass ionospheric storms and the zodiacal light and gegenschein. The theory placed the main seat of magnetic disturbance in the ionosphere. It pointed out that in the ionosphere above about 130 kilometers, where the free paths of the ions and electrons are longer than their radii of magnetic gyration, the ionization drifts in a horizontal direction under the action of the crossed magnetic and gravitational fields. The velocity of drift is mg/He , the positive ions moving eastward and the negative ions and electrons westward; m and e are the mass and charge respectively, of the ion,

and g is the acceleration of gravity. This amounts to an eastward electric current encircling the earth. The gravitational-magnetic drift current is a maximum at the equator, since there the ionization is a maximum and the gravitational and magnetic fields are perpendicular to each other. The current decreases with increasing latitude, because the ionization and the angle between the gravitational and magnetic fields decreases at the higher latitudes. Therefore, in the F region of the ionosphere there is an equatorial electric current flowing eastward around the earth at all times, which in conditions of a quiet sun is of the order of 10^6 amperes and produces at the equator a horizontal magnetic field of the order 100 gamma. This ring current is assumed to be always present in the ionosphere and hence its field, which is external to the earth, adds to the permanent field of the earth, but is too small to be confirmed or denied by analysis of that field.

A magnetic storm of the worldwide type was assumed to be caused by a sudden flare of ultraviolet light from the sun. This does several things. It first increases the ionization in the F region of the ionosphere which increases the eastward ring current around the earth and causes the first phase of the storm. Then the flare was assumed to heat the atmosphere in the F region. The heating causes an outward expansion of the outer atmosphere which produces two reactions, a dynamo effect and an "engulfing" effect. The dynamo effect results from the upward movement across H and is a maximum near the equator where H is horizontal. It induces a westward current around the earth which reduces H . It was calculated that an upward velocity of 10 kilometers an hour would reduce H by about 100 gamma at the equator. The engulfing effect, also a maximum in tropical latitudes, depends on the fact that where H is approximately horizontal the long free path ions can move only a short distance across H between collisions and are therefore hindered from moving upward freely with the neutral particles of the expanding atmosphere. Thus, after the initiation of the storm many of the long free path ions find themselves in a mounting tide of air molecules; their free paths are shortened and they become lost by recombination. This reduces the gravitational-magnetic eastward drift current below its normal value (relative to its normal value it may be considered as a westward current) and gives rise to the second phase of the storm. The heating also causes horizontal winds in the ionosphere, which produce magnetic storm irregularities.

The diurnal storm variations are attributed to

another set of actions. It is assumed that the ultraviolet solar flare causes over the daylight hemisphere an increase in the atomic and molecular particles which are sprayed outward to high levels from the outer fringe of the upper atmosphere. The translational energy may come from temperature collisions and from collisions with excited atoms and molecules. The particles reach altitudes of 30,000 to 50,000 kilometers from the earth in 2 to 4 hours. They become ionized and, since they are constrained by the earth's magnetic field, they fall back to the earth along the magnetic lines of force to auroral latitudes. There, part of their energy is emitted as auroral light, and part of their energy goes into winds and increased ionization which cause the diurnal magnetic storm effects. The wind part of the theory was considered to be very important, but it was described qualitatively and not quantitatively. The theory is illustrated in Fig. 1.

It is not the purpose here to give the quantitative development of the ultraviolet flare theory, or to describe the indirect evidence adduced in favor of the theory, such as the observed delay of several hours between the incipience of a magnetic storm in tropical latitudes and the appearance of associated polar auroral displays, the greater spreading of the aurora into lower latitudes with increasing intensity of the magnetic storm, and the fact that the aurora has an air spectrum. A particular type of magnetic disturbance, known as a magnetic "bay" or "crochet" was discovered to occur within 2.5 minutes after bright hydrogen H_α flares on the sun. It was believed for a time that the crochet was merely an intensification of the normal quiet day diurnal variation in the earth's magnetic field.⁵ More recent results⁶ showed that this was not so, but that the crochet was a storm type of disturbance. Thus, one type of magnetic disturbance is known to be caused by an emission from the sun that has a velocity 30 per cent that of light.

The aurora part of the theory has been criticized² by Chapman and others, who advanced arguments that there may not be enough outer atmospheric spray to account for the aurora, that the ionization descending into polar latitudes cannot reach altitudes of 100 kilometers where the aurora occurs, and that the theory cannot account for the observed thinness of auroral curtains. The arguments are theoretical and cannot be regarded as decisive. In the end the real question is, "Does the sun cause terrestrial magnetic disturbances and aurorae, by bathing the earth in a flare of ultraviolet light (or short wavelength radiation of some

sort), or by spraying the earth with corpuscles (charged or uncharged), or by both?" At the present time experiment has not answered the question, but there is some evidence that both effects may occur. Another fundamental question is, "Is the seat of the magnetic storm in the ionosphere?"

Ionospheric Storms

It has long been known that abnormal ionospheric activity is closely connected with magnetic activity.⁷ Therefore if magnetic storms are due to disturbances in the ionosphere one might hope that knowledge of the ionosphere might lead to a clearer understanding of the electromagnetic phenomena there which cause the magnetic storms. The hope has not yet been realized because, although ionosphere stations have been accumulating data for 20 years, the data have not yet been completely analyzed on a worldwide scale. Such analyses have been begun but at the present time conclusions from them are in some respects incomplete or ambiguous. Ionospheric records are usually taken every 15 minutes or every hour, which often is not frequent enough. The records often go off scale and are often partially or completely blanked out during magnetic storms. There are not enough ionospheric stations in certain geographic areas, and the routine radio pulse method of ionospheric probing gives only a few data about the ionosphere, which are often ambiguous or difficult to interpret. The situation is analogous to an attempt to learn about weather in the United States by means of, say, only 10 weather stations which recorded only the pressure at three altitudes, and which often lost their records during strong storms.

The ionospheric changes during a magnetic storm are very complicated. An extreme case was brought out by Berkner and Seaton⁸ in a detailed examination of the records of the ionosphere stations at Huancayo, Peru, and at Watheroo, Western Australia, during the magnetic storm of March 24, 1940, which was the most violent ever recorded. At Huancayo during the first great magnetic changes the F_2 layer was swept upward (apparently) and disappeared in about 30 minutes. At the same time the ion density of the E layer rose about 40 per cent. Growth of a new F_2 layer began in an apparently normal manner for the next hour which was followed by a succession of abnormal increases and decreases during the next 12 hours. At Watheroo there was a great rise in height of the F_2 layer, which lagged behind that at Huancayo by about an hour. Also at Watheroo

there was evidence of large spatial tilts of isoionic surfaces.

Statistical analyses of the data from many ionospheric stations have been begun by Appleton and Piggott⁹ and by Martyn.¹⁰ Martyn concluded that the ionospheric storm at all latitudes began either simultaneously with, or in a time less than one hour after, the commencement of the corresponding worldwide magnetic storm. Appleton and Piggott concluded that at high latitudes in the auroral zone there was a close connection between magnetic perturbations and disturbances in the F_2 region, the critical frequency (which is proportional to the square root of the maximum electron density) being decreased and the height of the layer greatly increased during periods of magnetic activity. At lower latitudes these fluctuations were replaced by more regular and longer perturbations which often showed a biphasic structure. The structure was most evident in winter and in years of minimum solar activity. It consisted of a positive phase, during which the critical frequency was above normal, followed by a negative phase in which it was suddenly greatly depressed and required one to several days to return to normal. Appleton and Piggott and Martyn agreed that the perturbations of F_2 region during magnetic storms depended markedly on the season and the local time. In respect to certain further details they appear to disagree. But their work is unfinished (or has not yet been completely published), and since they, and indeed everyone, uses, or has access to, the same ionospheric data (the CRPL monthly issues), there is no reason to suppose that agreement may not be reached about the facts of ionospheric storms.

It is obvious that certain of the facts of ionospheric disturbance, which were discovered long after the inventions of the ultraviolet flare theory, are qualitatively favorable to the theory. The turmoil observed in the ionosphere during its storms is in keeping with the theoretical ideas of increases in ionization, heating, and winds in the upper atmosphere occasioned by the flare. The biphasic phenomena of an increase in ionization at the beginning of the storm followed by a decrease agree with the parts of the theory which contemplated an eastward ring current followed by a reversal, or westward current. However, as yet little quantitative support of the theory can be derived from the ionosphere facts, because these refer mainly to values of maximum electron density, whereas the theory requires a knowledge of total

electron and ion densities and their distribution in altitude.

Corpuscular Theory

Although several solar corpuscular theories of magnetic storms and aurorae have been proposed, they are in an inchoate state and have not reached the point where they profess to explain very much. An early theory was the simple one invented by Birkland¹¹ and later developed in mathematical detail by Störmer.¹¹ It was assumed that the sun projected toward the earth a stream of particles, electrons, or ions, all charged with the same sign. These would be diverted by the earth's magnetic field and do two things; some would enter polar regions and cause aurorae, and others would swing about the equator in a way not explained to form a sort of ring current. But Schuster¹² raised a difficulty when he pointed out that this cannot happen to a stream of like particles, because their electrostatic repulsion would disperse the stream long before it reached the earth. To avoid the difficulty, Lindemann¹³ suggested that the particles be charged equally positive and negative, so that the stream as a whole is electrostatically neutral. The suggestion has created as many difficulties as it attempted to resolve. Chapman and Ferraro^{2,14} have made a determined effort to develop the neutral ionized gas stream idea. Recently Chapman¹⁵ concluded that some real but limited progress toward a theory of magnetic storms has been made, but much less toward a theory of aurorae.

The neutral ionized gas stream theory of Chapman and Ferraro is illustrated in Figs. 2, 3, and 4,

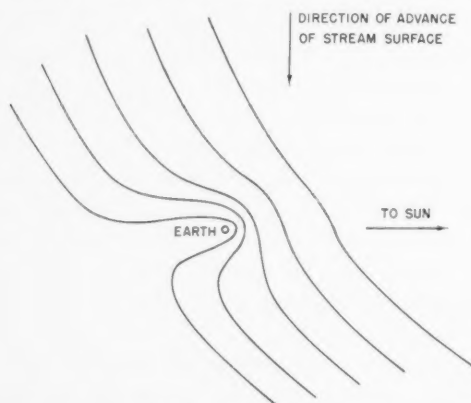


FIG. 2. Neutral ion stream theory, early stage.

which are drawn to scale. The lines of Fig. 2 indicate the advancing front of the solar corpuscular stream. As the stream nears to within about $10R$ (R is the radius of the earth) or 60,000 kilometers from the earth, a dent is formed in it by the magnetic field, Fig. 2. Owing to the induced

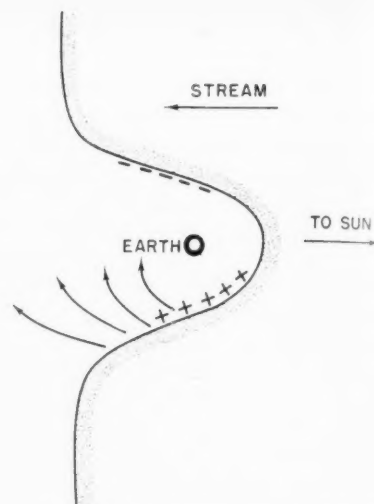


FIG. 3. Neutral ion stream theory, later stage.

currents in the front caused by its advance into the magnetic field, the magnetic field over the entire earth is suddenly intensified. This is the first phase of the magnetic storm. For an intensification of 20 gamma at the equator, the following numerical values were suggested,¹⁵ speed of corpuscles 1000 km sec^{-1} , number density in the dent 1 to 100 cm^{-3} , and nearest approach of the surface of the hollow to the earth $5R$ or 300,000 kilometers. Charges appear on the sides of the dent as shown in Fig. 3. This explanation of the first phase of the storm is as far as the theory has been carried with reasonable physical justification. The remainder of the theory is purely speculative.

In order to account for the second or major phase of the storm it was suggested that somehow the positive charges on the dent jump across the gap behind the earth as indicated in Fig. 3, and eventually build up a westward ring current, Fig. 4, which would cause the second phase of the storm. The formation of such a ring was admitted to be speculative. However, on the assumption that the ring was formed, it was calculated that the ring would be stable under certain conditions of rotational speed around the earth and current carried by the ring. Numerical estimates¹⁵ were, inner radius 20,000 kilometers, thickness 3000 kilometers, total mass 10^7 to 10^9 grams, particle density 10^3 to 10^5 cm^{-3} . Owing to the motion of the ring across the earth's magnetic field there will be a positive charge on the inner surface and a negative charge on the outer surface, with a potential difference of the order of 10^6 volts between the surfaces. It was suggested by Martyn¹⁶ that this potential would shoot charged particles along lines of magnetic force to auroral regions,

which may have something to do with aurorae. Whether the ring was only formed during magnetic storms, or whether it exists all the time, and waxes and wanes with magnetic disturbance, was undecided.

Martyn¹⁶ has carried the speculations about the corpuscular theory a little further in order to consider the diurnal storm effects. He dealt with the complicated drift motions of the ions in the crossed magnetic and electric fields, the electric field being from ring to earth. Alfvén¹⁷ has invented another variation of the neutral ionized stream hypothesis by assuming a small solar magnetic field and putting aside electrostatic attraction of the positive and negative charges. In all these attempts the real difficulty has been that no one has yet been able to work out what happens when an ionized neutral cloud of gas sweeps over a rotating magnet. But, as described in the next section, the difficulty may disappear, because corpuscular emissions from the sun probably arrive at the earth as charged streams and not as a neutral cloud.

Aurorae

We now come to the recent very beautiful experiments of Meinel¹⁸ on the aurora. He built small spectrophotographs of great light-gathering power and with these instruments was able to obtain spectra of limited regions of the sky with exposures of only 20 to 40 minutes, and thereby to observe short-lived spectral features of auroral displays which had never been seen before. When the spectrograph was pointed at a quiet auroral arc in the magnetic zenith, the red hydrogen line H_α was observed with diffuse Doppler broadening to shorter wavelengths, indicating protons entering the upper atmosphere at high speeds, the Doppler spread reaching 3000 km sec^{-1} . The protons of course cannot emit H_α , but can do so when they have slowed down sufficiently to capture electrons into the third Bohr level. Therefore, the result was interpreted as indicating that their speeds of approach to the earth were nearer to 10^9 rather than 10^8 cm sec^{-1} . Such speeds would enable the protons to penetrate to about 100 kilometers where the quiet auroral arcs occur.

At the same time the lines of N_2 , N_2^+ , and O (I), which were also present with H_α in the quiet arc spectrum, had no one-sided Doppler spreading, indicating that these emissions arose from impacts of the protons with nitrogen and oxygen molecules and atoms of the upper atmosphere. The H_α emission was concentrated near the bottom of the auroral arc, and decreased with height much more

rapidly than the other emissions, which was evidence that the protons created a large column of ionized and excited particles on their way down until they were sufficiently slowed up to be able to capture electrons and emit Balmer radiations.

Further observations by Meinel and Gartlein¹⁸ indicated the following pattern of events in an auroral display. The presence of the quiet auroral arc with strong H_α emission was characteristic of the commencement of the display. After a time, which varied from minutes to hours in different displays, the quiet arc broke up, coinciding with abrupt ending of H_α emission, and the rapidly changing luminous features of display set in, such as rays and flaming clouds, as if the incoming protons were the primary excitation source and the rays and flaming structures were after-effects. One may picture that the incoming protons absorbed at the 100-kilometer level blasted out the atmospheric oxygen and nitrogen molecules to great heights.¹⁹

In order to explain how high-speed protons may be deflected to auroral zones a new theory of the aurora has been developed by Bennett and Hulburt²⁰ based on magnetic self-focusing effects of ionized streams. These effects modify and counter-

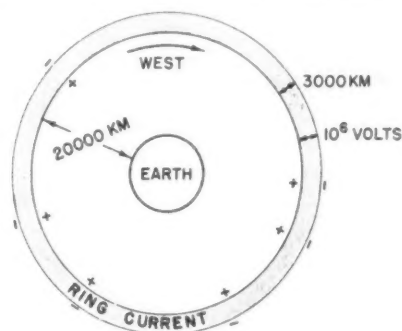


FIG. 4. Ring current, neutral ion stream theory.

act the electrostatic spreading effects in such streams; they were worked out in 1934 in some detail by Bennett.²¹ In the theory it is assumed that the sun emits a conical stream of positive ions (either protons or other types of ions) and negative electrons in equal numbers and at first of equal speeds. The free path of a charged particle moving through a completely ionized gas depends approximately on the fourth power of the speed and the square of the mass of the particle. Therefore, as the stream passes out through the ionized atmosphere of the sun (the corona), the electrons experience many more collisions than the ions and are slowed up or thrown out of the stream. But, because of electrostatic forces the electrons are continually replaced in the stream from the slow

electrons of the surrounding ionized gas. The stream of positive ions continues and constitutes an electric current; but at all times all parts of the stream and the surrounding gas are closely (but not exactly) electrostatically neutral. Due to the magnetic field of the electric current the fast-moving positive ions are continually compressed into the stream, and the electrons and the slower positive ions are continually ejected from the stream. This is termed "magnetic self-focusing." The stream develops into a narrow core of fast-moving positive ions which progresses through space and, if correctly aimed, enters the influence of the earth's magnetic field. It is there diverted to auroral zones according to the calculations of Störmer. The stream is pictured in Fig. 5.

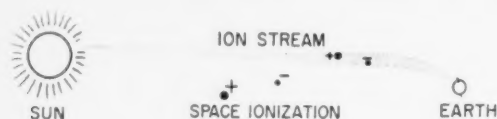


FIG. 5. Magnetic self-focusing ion stream, auroral theory.

Now, if the space between the sun and the earth were a vacuum, the stream of positive ions would be immediately dispersed by electrostatic repulsion, and would cease to exist. Therefore the theory requires that the space between the earth and the sun be filled with an ionized gas, and that the density of the gas be greater than a certain lower limit which depends upon the strength of the electric current of the stream. Calculation shows that for a positive ion current which carries an energy equal to that of an auroral display the density of ion electron pairs in the space between the earth and the sun must be greater than about 10^{-2} cm^{-3} . A density of ionization of this amount, and even up to five orders of magnitude greater, appears to be open to no objection. But its existence cannot be said to have been proved by experiment, and it therefore remains at present an essential hypothesis of the theory.

If such a density of ionization exists between the sun and the earth, it follows that the neutral stream theory of magnetic storms of Chapman and Ferraro,¹⁴ pictured in Figs. 2 and 3, is not possible, because such streams would be magnetically self-focusing and would cause terrestrial magnetic effects quite different from those which they have calculated.

We may sum up the results of efforts to invent magnetic storm and auroral theories by saying that at present the most reasonable hypothesis is that the sun emits a flare of ultraviolet light together

with a spray of ions and electrons. The ultraviolet light causes changes in the ionosphere which give rise to the magnetic storm, and the ions proceed as a magnetically self-focused stream to high latitudes to cause aurorae and magnetic disturbances.

Zodiacal Light and Gegenschein

The zodiacal light and the gegenschein are gentle luminous apparitions of the night sky, familiar to those who spend many clear nights in the open, but not so to others. They may not be very important or vital phenomena, but are of interest in the present discussion of interplanetary phenomena. They seem to be far away, at least several thousand kilometers, but their distances from the earth have not been determined exactly, because they exhibit no sharp features suitable for triangulation or parallax measurement. The explanation of the zodiacal light that has reposed undisturbed for many years in textbooks is the planet dust theory. The theory, illustrated in Fig. 6, con-

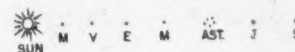


FIG. 6. Zodiacal light, planet dust theory.

templated a lenticular cloud of dust spread out in the ecliptic plane of the planet system around the sun. It was believed that the dust particles could not be molecules, since, due to diffusion and light pressure, molecules would not remain in the cloud, unless there were a continual supply. The particles were therefore considered to be small solid bodies, each moving in its independent orbit around the sun. The sunlight reflected by these bodies is the zodiacal light, and, if they were large with respect to the wavelength of light, the zodiacal spectrum should be the same as the solar spectrum.

However, particles smaller than a certain size would fall into the sun because of the braking action of solar radiation due to the Poynting-Robertson effect.²² The size depends on the time since the particle entered its orbit, and Urey²³ has recently calculated that for a time 3×10^9 years all rocks (density 3.3) of diameter less than 15 centimeters, would have fallen into the sun throughout a distance of 3 A. U. (4.5×10^8 kilometers) from the sun. Rocks of diameter 15 centimeters, albedo 0.1 for sunlight, and about 10^3 kilometers apart would account for the observed zodiacal luminosity.

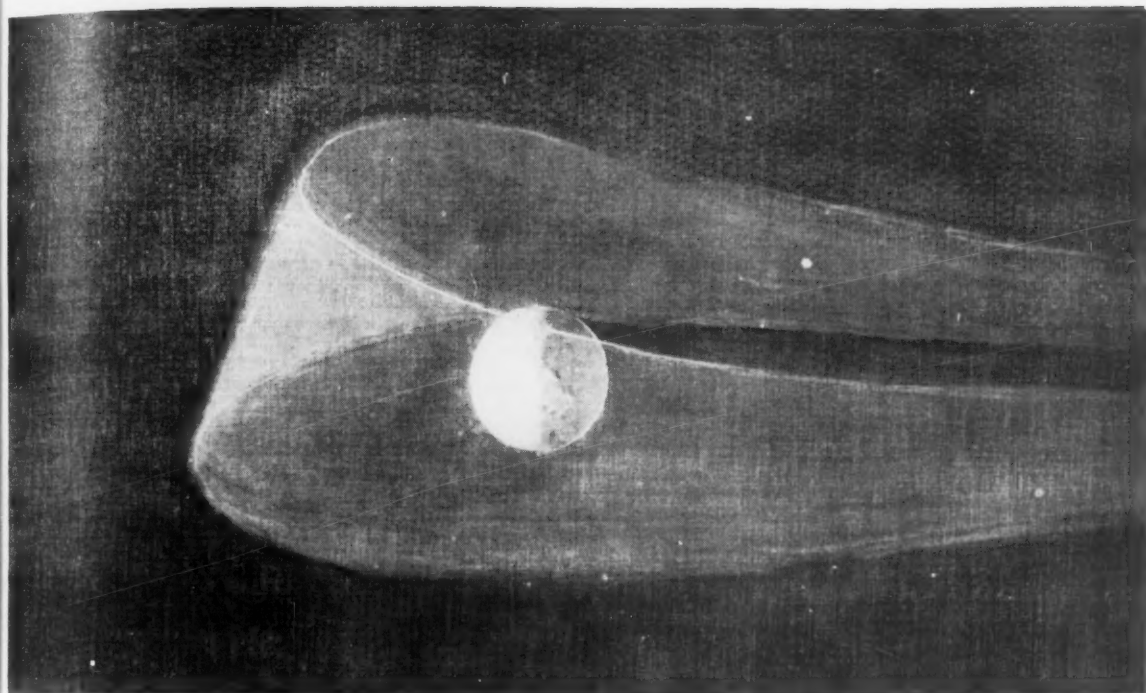


FIG. 7. Zodiacal light, atmospheric ion theory. From a painting by Charles Bittinger.

Fessenkoff²⁴ has given the most recent and critical development of the dust theory. He assumed that a dust theory must account for a dust cloud whose density decreased somewhat more rapidly than inverse distance from the sun, of oblateness 4/5, the dust being continually replaced, because of the Poynting-Robertson loss. Since the disintegration of comets by a planet was too slow and would yield too flat a system, he assumed that the dust comes from collision between sporadic interstellar meteors and asteroids. In support, he recalled that the moon and Mercury appear to have a surface layer of dust, as if caused by a gradual shattering of surface rocks by meteors. Thus the formation of dust appeared to be a process which is continually going on in the solar system. But while a massive planet or satellite retains the dust on its surface, a small asteroid is more than likely to lose it. Since the integrated exposed surface of all the asteroids is enormously larger than that of a major planet, the process of dust formation must be especially efficient within the ring of asteroids.

Fessenkoff then carried out a mathematical investigation to see what the velocity V_0 must be of the dust particles, which arise from impacts of interstellar meteors with asteroids, relative to the orbital velocity U of the asteroid, in order to have the correct sort of dust cloud. He concluded that V_0 must greatly exceed U and be confined within

fairly narrow limits. All this placed severe restrictions on the properties of the colliding meteors. He remarked that radiation pressure was omitted from his calculations.

The gegenschein, or "counterglow" is the slight (less than 50 per cent) increase in the luminosity of the zodiacal band opposite the sun. Three suggestions to explain it, from the point of view of the dust theory, have been made. The first was based on the idea that the dust particles, like full moons, reflect more light to the earth from the region of the gegenschein than those in other portions of the zodiacal band. The second was based on a particular solution of the problem of three bodies,²⁵ which gave reasons for supposing that there might be an increase in the density of the dust particles in the antisolar direction. The third, due to Barnard,²⁶ was that the atmosphere surrounding the earth acts as a lens to give a concentration of light on the dust particles in the antisolar direction. The three suggestions have not been examined critically. Indeed this may be difficult to do, and they have neither been proved nor disproved. They are based on good physics, but their validity is dependent on the validity of the dust theory.

There appeared to be evidence that the zodiacal light exhibits variations in brightness during magnetic disturbance. Such variations were not ex-

plainable by the dust theory, and an atmospheric ion theory was invented.²⁷ This was an extension of the ultraviolet solar flare theory of magnetic storms and aurorae. The theory was developed in quantitative detail, but we give here only the essential physical ideas. It was assumed that due to the energy of the solar ultraviolet light absorbed in the upper atmosphere there is always a neutral spray of high-flying atmospheric atoms and molecules over the daylight hemisphere which shoot out to great distances. After several hours they are ionized, and at levels beyond 30,000 kilometers drift under the action of solar radiation pressure and the earth's magnetic and gravitational fields to form a sort of ion and electron oblong ring around the earth approximately in the plane of the ecliptic. The ions absorb sunlight in the far ultraviolet region of the spectrum and re-emit a part of the absorbed energy as visible light. This is the zodiacal light. The portion of the ion ring away from the sun streams away under light pressure in a long tail, like a comet's tail. Viewed end-on, this is the gegenschein. That the gegenschein may be a comet tail appendage of the terrestrial atmosphere was suggested long ago by Arrhenius, Evershed, and others.²⁷

The results of the atmospheric ion theory are sketched in Fig. 7, which however does not show the thickness of the zodiacal veil conceived by the theory. On the side toward the sun the zodiacal veil was estimated to extend from 30,000 to 50,000 kilometers from the earth, with the particle density of the order of 10^2 ions cm^{-3} , which is probably undetectable by radio probing. The magnetic effect at the earth was only a few gamma, also undetectable. The zodiacal light and the gegenschein are the last fleeting glimpses of atmospheric particles which are leaving the earth never to return. If the theory is correct the spectrum of the zodiacal light and the gegenschein should be different from that of sunlight and should show emissions of atmospheric gases.

Spectral observations of the zodiacal light are difficult because, due to the earth's rotation, the brightest part of the zodiacal light is visible for only about a half hour after evening and before morning twilight, and is usually not more than 1.5 times as bright as the neighboring region of the night sky at the same altitude above the horizon. Therefore spectrographs and photographic plates of the highest possible speeds, and very clear air, are required to obtain adequate spectra; such spectrographs are of low dispersion. Furthermore, the night sky spectrum is always superimposed on the zodiacal light spectrum, together with the

spectra of any stars which may be in the field. These considerations may explain the lack of agreement which exists at present in the observational results. In 1932 Ramanathan and Karandikar²⁸ obtained a zodiacal light plus night sky spectrum with an $f/1.5$ spectrograph and concluded that it showed an enhancement of the oxygen green line 5577, as compared with the night sky, and no Fraunhofer lines. In 1935 Cabannes and Dufay²⁹ with an $f/0.7$ spectrograph concluded that the Fraunhofer F, G, and H lines were present in the zodiacal light plus night sky spectrum and no enhancement of 5577. More recently at the Gorna Astrophysical Observatory, near Alma Ata, USSR, spectra were obtained of both the gegenschein³⁰ and the zodiacal light,³¹ which showed mainly the enhancement of night sky lines. Reproductions of the spectra were not published. Fessenkov³⁰ interpreted the gegenschein spectra as indicating that the gaseous origin of the gegenschein was fairly probable, and adopted the comet tail explanation of the gegenschein. However, he apparently still clung to the dust theory of the zodiacal light. Tikhov³¹ used two $f/0.5$ spectrographs to photograph simultaneously the spectra of the zodiacal light plus night sky and of the night sky alongside the zodiacal light. Two sets of spectra were taken, one set from October 25 to December 4, 1946 (exposure time, 32 hours), and one set from November 17 to December 22, 1947 (exposure time, 32 hours and 20 minutes). Measurements of the green oxygen line 5577, the yellow sodium doublet 5890, 5896, and the red oxygen pair 6300, 6364 Å, showed that each of these was, within experimental error, 34 per cent stronger in the zodiacal light plus night sky than in the contiguous region of the night sky alone. This result supported the atmospheric gas origin of the zodiacal light.

In conclusion, there are two effects which at all times have confused thinking about the outer fringe of the earth's atmosphere. Whether the effects are important or unimportant cannot be said; all that one can do is to keep them in mind and remain in a state of uncertainty. The two effects are the sweep-up by the earth of interplanetary material and the electric charge brought to the earth by cosmic rays. If there were material in the space through which the earth moves in its orbit around the sun amounting to 10^4 molecules cm^{-3} , the sweep-up due to an orbital velocity of 20 km sec^{-1} would be 2×10^{10} molecules $\text{cm}^{-2} \text{ sec}^{-1}$ striking the earth, and the possible effects which these would produce in the upper atmosphere might be greater than those which have

been considered in the foregoing theories. Similarly for material in the form of dust, meteors, or charged particles.

If the primary cosmic rays are protons only, and at present there is no evidence of a negatively charged component, then on the basis of 1 proton $\text{cm}^{-2} \text{min}^{-1}$ of energy 10^{10} electron volts there would accumulate on the earth in 16.5 years a positive charge of 7×10^6 coulombs, which would be sufficient to prevent any more protons, of energy 10^{10} electron volts or less, from striking the earth. Presumably this amount of positive charge does not accumulate, because cosmic rays continue to bombard the earth, and therefore there is some mechanism of escape, or neutralization, of charge. But presumably in the steady state balance between rate of accumulation and rate of loss of charge there might be some small quasi-permanent charge left in the upper atmosphere of the earth. And it does not require a very large amount of charge, less than 10^2 coulombs, to modify profoundly any of the foregoing theories of magnetic storms, aurorae, and zodiacal light.

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Morning zodiacal light, Bocaiuva, Brazil. (Photograph by Edward O. Hulburt.)

On the Dynamics of Motion Sickness in a Seaway*

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ANACHARSIS, an ancient mariner of antiquity, once stated: "People may be divided into three classes: those who are alive, those who are dead and those who are at sea!" That statement is as true today as it was in 600 B.C., for seasickness may reduce a robust man or woman to a sorry spectacle when "the winds blow great guns" and "the sea is mountains rolling." Nearly every modern mariner and most passengers have experienced weakness in the knees before their sea legs buckled, or have been all but overcome by a repulsive void in the pit of the stomach when the ship "reels and staggers like a drunken man" through the halt and hurl of an angry, crashing, tempestuous seaway. Many men both of kindred and diverse tongues have been the temporary victims of motion sickness so extreme that they wished they were dead "when the breast of the waters is ploughed like a field by the gale, and the ocean is turned up and rent in long furrows of foam."⁷

That seasickness is a factor to be reckoned with and respected, even in the United States Navy, is evident from the official records of the Bureau of Medicine and Surgery of the Navy Department. The incidence rate of motion sickness during World War II was 102.9 per 100,000 sailors. The size of the Navy increased from 834,639 in 1942 to 3,673,855 by the end of 1945. The average strength of the Navy and Marine Corps for this four-year

period, as reported in Volume 3 of "The History of the Medical Department of the U.S. Navy in World War II" (NAVMED P-1318), was just under two and a half million. More than 250,000 men were admitted to the sick list for seasickness during 1942-1945. Such patients were "noneffective" for an average of eight days, a loss of two million man-days. Moreover, 10,500 men were released from active duty and returned to civilian life during World War II because of "incurable" seasickness. A comparable experience was recorded during the Korean conflict (1950-1953) when 51,655 sick days were accumulated by 1983 seasick sailors, 869 of whom were "invalided" from the Naval Service because of their malady. Presumably, their physiologic response to common ubiquitous physical forces was almost identical. Yet the dynamic characteristics of these basic forces of motion have never been clearly or quantitatively delineated.

Physical forces acting above and below the surface of the sea impart dynamic motion to any floating object. By definition, dynamics is that branch of physics describing the changes of motion produced by mechanical forces. Motion sickness is a general term applied to a variety of conditions akin to seasickness, such as nausea and vomiting produced by riding in airplanes, trains, trolley cars, automobiles, small boats, swings, merry-go-rounds, and elevators. There is one factor common to all and that is rhythmic, dynamic motion.

Although most mammals can be affected to some degree by rhythmic motion, there appears to be both an individual and species predisposition or resistance to motion sickness. Horses, dogs, cows, and sheep frequently become seasick; cats, canaries, and monkeys seldom do. Deaf mutes and individ-

* This is based on data obtained when the author was Director of the Research Division, Bureau of Medicine and Surgery, Navy Department. The opinions or assertions are the author's and are not to be construed as official or as reflecting the views of the Navy Department.

† The author is indebted to many officers and individuals who participated in this study and to those who gave permission to quote their findings.

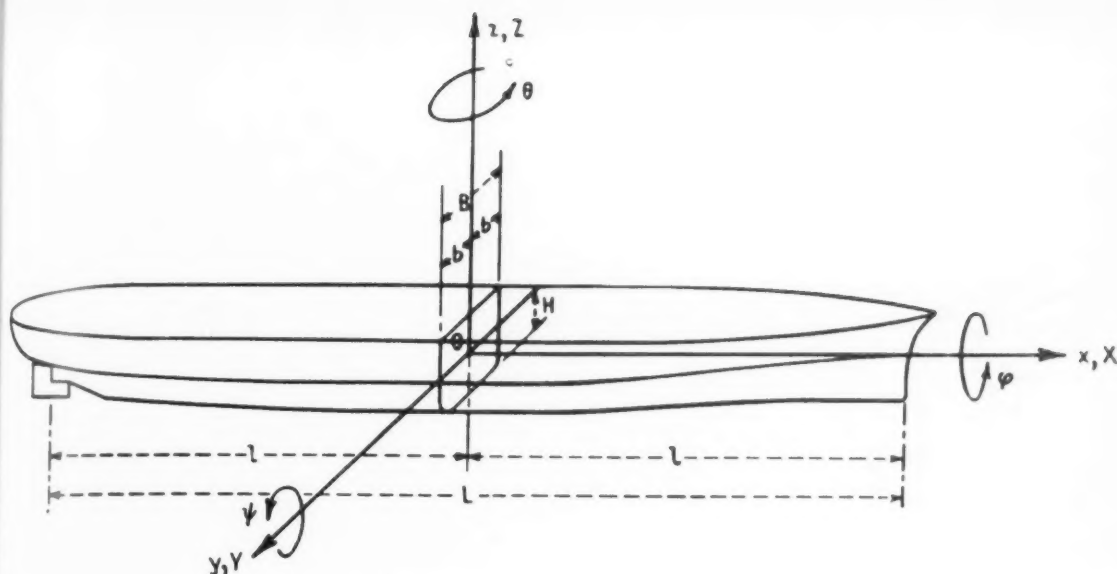


Fig. 1. Demonstrating the six types of motion of a ship in a seaway (or an airplane in flight). As indicated by the Greek letters ϕ , ψ , and θ , pitch, roll, and yaw occur around or about the orthogonal axes, X , Y , and Z . Motions along these axes, shown by small x , y , and z , are termed surge, sway, and heave. The combined effect of all six degrees of freedom of motion may be irresistible, both physiologically and hydrodynamically. O , the origin at the center of gravity, is assumed at midsection.

imals with permanent damage to the delicate mechanisms of the inner ear usually do not experience motion sickness. Yet illness can be induced in nearly every normal person by certain types of motion applied under special conditions.¹ In all cases the physiologic stress and distress are mediated by way of special nervous pathways in the spinal cord and midbrain to the cerebellum and cerebrum. The vestibular apparatus of the inner ear, including three semicircular canals at right angles to each other, responds to motions along or around the three coordinate axes in the horizontal, lateral, and vertical planes. Changes in position stimulate the complex mechanism within the semicircular canals and initiate certain reflex patterns in the central nervous system which excite skeletal muscles, tendons, and joints to maintain body equilibrium.¹³ Since no difference has been noted in the vestibular mechanisms or nervous pathways of various mammals or of individuals within a species who may be susceptible or resistant to the effects of motion, much study will be required to delineate the various factors responsible for motion sickness. One basic common mechanical factor, frequently overlooked, is the dynamic action of linear acceleration and deceleration.⁸

During World War II the problem of airsickness was intensively studied, as cited by Tyler and Bard.¹² Eleven percent of the cadets became ill during their first ten flights. Fifteen percent of the air crews during training, and 65 percent of the navigators on

long operational flights at times experienced nausea and vomiting. Airsickness in paratroopers swinging down to earth was found proportional to the degree of atmospheric turbulence. At sea, 90 percent of the totally inexperienced may become ill on their first voyage if the passage is extremely rough. Similarly, troops of the U.S. Marine Corps riding in landing craft during amphibious operations frequently experienced seasickness sufficient to decimate their fire power just before assailing the beach. The significance of motion sickness to military operations is obvious. Surely, no soldier, sailor, airman, or marine who is engaged in vomiting will have much "stomach" for engaging the enemy in mortal combat.

Psychology

The symptoms of motion sickness vary in their time of onset, intensity, and duration, depending on several factors: the vehicle, the type of motion, and the nervous tension of the individual. Visual illusions of motion often magnify the vertiginous effect of alternate or rhythmic acceleration and deceleration. Apprehension and other psychologic influences, including the response conditioned by the unpleasant sight of watching others vomit, may play an important role in the symptomatology of seasickness. Inadequate ventilation apparently precipitates vomiting in many nauseated persons. Obnoxious odors from the paint locker and the galley are notorious offenders in this respect. Yet those who

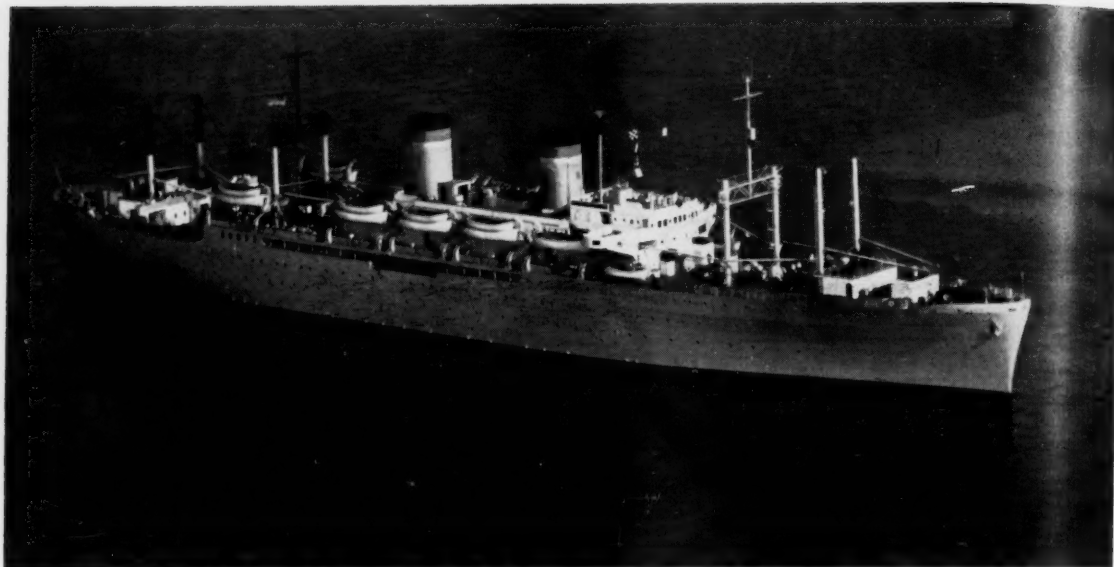


FIG. 2. The USNS General Alexander M. Patch (T-AP122), equipped with inclinometers to measure pitch and roll and integrating calibrated accelerometers to record heave.

must work in hot, humid, and confined spaces or have heavy responsibilities which must be fulfilled in order to keep the ship under way and in operational readiness for combat seldom succumb to seasickness. Conversely, timid passengers are more prone to become seasick because they do not have enough to do to occupy their minds.¹⁵

However, the significance of psychological factors in the production of seasickness may be more apparent than real. Surely, the power of mind over matter sheds little light on the mechanics of motion sickness. Certain physical forces appear to be fundamental and, when applied within a set of given circumstances, are thought to be common to all forms of motion capable of inducing vertigo and vomiting.

Dynamics

The motions of a ship at sea depend, by and large, on two factors: the state of unrest or turmoil of the surface water and atmosphere, and the response of the ship thereto. Many variables complicate the study of the composite motions of a ship.⁴ The attitude of a floating vessel at any given moment is the result of several interacting factors: the condition of the sea, the specific parameters of hull form and loading, and the ship's speed and course. These factors have been subjected to extensive, critical analysis, mathematically, and are under intensive investigation by naval architects. Despite the combined efforts of many expert mathematicians, the problems of the motions of a ship in a seaway have not been solved in their entirety. This is largely because of the difficulty of obtaining

simple analytical expressions for the constantly changing surface of the sea, the resultant forces acting on the hull, and the speed and course of the ship.¹⁴

The forces exerted upon a floating vessel constitute a dynamic system with at least six directional components or degrees of freedom. The wind and sea may displace the ship's center of gravity along three orthogonal axes fixed in space or may cause her to rotate about these axes (Fig. 1).

Oscillatory linear motions along the longitudinal, lateral, and vertical axes are termed surge, sway, and heave. Rhythmic oscillations about these same axes are termed pitch, roll, and yaw, respectively. The plunging and leaping motion of a ship in a heavy sea is known as pitching; the side-to-side movement is called rolling. The term yawing is reserved for the swing of the ship off course when overtaken by fast-moving seas approaching from aft which lift the stern high, throw the bow down, and shove the ship around. As the swell passes, the ship tends to swing back to her original course. Swaying refers to a sideward set and return; surging is a forward-and-backward set and recovery. Heaving, or "scend," is an oscillatory motion much like that of a cork bobbing on a wave. It may be defined also as the linear displacement in a vertical plane of the center of gravity of a ship. This occurs whenever the vessel ascends to the crest or descends to the trough between two waves.

Surge, sway, and heave, being linear motions, imply linear accelerations. But since roll and pitch and yaw are angular motions, their changing veloci-

ties imply angular accelerations. However, by multiplying the angular accelerations by their distances from the axis of rotation, which is assumed to be the ship's center of gravity, they can be transformed into linear accelerations for a given point at any given instant. As such, they may be added to the linear accelerations due to surge, sway, and heave to obtain the total linear acceleration at that point in feet per second per second. The linear accelerations of heave and pitch represent the motions of greatest magnitude.¹¹

Both pitch and roll may be measured by means of inclinometers and expressed in degrees as angles of displacement from the ship's horizontal and longitudinal axes respectively. However, heave cannot be measured when out of sight of land because there is no point of reference in a seaway. To determine quantitatively the displacement of the ship's center of gravity in or along its vertical axis while at sea, it is essential that that vessel first be equipped with calibrated, integrating accelerometers.

Sea Trials

In an attempt to quantitate the motions of a ship and the incidence of seasickness, a correlative study was made aboard two vessels of the Military Sea Transportation Service (Atlantic) in 1951 during routine crossings from New York to Bremerhaven and return. As far as is known this is the first scientific sea trial of its kind ever attempted.¹⁰

Aboard the *USNS General R. E. Callan*, a C-4 type vessel of 19,915 tons displacement, inclinometers were installed to measure pitch and roll continuously. The pitch and roll recorder was designed and built by the Materials Laboratory of the New York Naval Shipyard. The unit was designed around existing gyro-stable elements. Rolling and pitching amplitudes in degrees were recorded as continuous traces on chart paper. Two constant-rate paper feeds were used: a slow rate at 15 inches per hour for compilation of statistical data, and a faster rate of 1.5 inches per minute for studying transient effects over intervals of relatively short

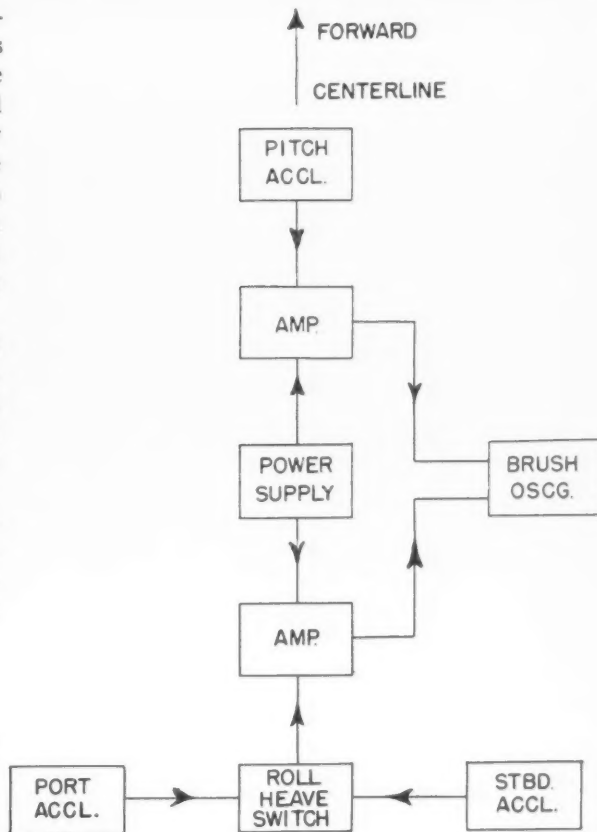


FIG. 3. Block diagram demonstrating location of the instruments to record accelerations produced by pitch, roll, and heave.

duration. The paper feed rate was checked by stopwatch from time to time.

The pitch and roll recorder was mounted close to the center line in the stateroom A-210 at frame 92, about 65 feet forward of amidship. The instrument was designed for operation at any location on board ship. Accelerations at various compartments were calculated from the pitching and rolling amplitudes and periods. It was assumed that the axis of roll was in the longitudinal plane of symmetry and that the axis of pitch was located at the center of

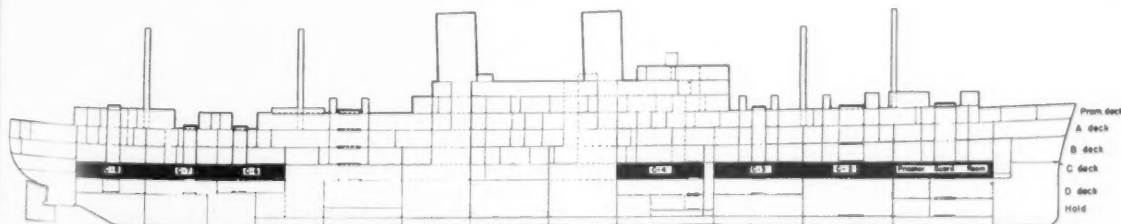


FIG. 4. Location of compartments aboard the *General Patch* where medical officers determined the actual incidence of seasickness.

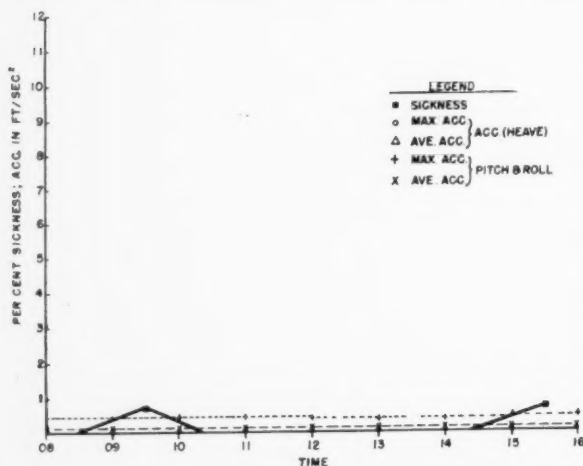


FIG. 5. Linear acceleration and percent sickness. When the sea was calm, as during the morning hours of Feb. 28, 1951, motions were almost negligible and the incidence of seasickness was almost nil.

gravity. Angular accelerations in various compartments were calculated from the amplitude and period of pitch and roll and were converted into and expressed as linear accelerations.

Six hundred and eighty-nine passengers aboard the *General Callan* were screened by officers in the Medical Division every four hours to determine the incidence of seasickness and its location in various compartments. Actual vomiting was required to confirm or establish the diagnosis. No factual or quantitative correlation could be demonstrated between the percentage of seasick passengers and the degree of pitch and roll. The maximum pitch of this vessel was 4.5 degrees (from the horizontal) at 0400 on Feb. 2, 1951. The period of pitch (double swing) was between 7 and 10 seconds. The maximum roll was 18.5 degrees from the vertical with a period of 14.9 seconds, double swing. The maximum angular accelerations were approximately 3 degrees per second per second. The calculated maximum linear accelerations in the compartments varied from 4.95 to 6.45 feet per second per second. Vertical acceleration (heave) could not be obtained or derived because this ship did not carry accelerometers.

Since roll and pitch, alone or in combination, could not be incriminated as the sole dynamic etiologic factor in motion sickness, an intensive study of the effect of heave (or scend) appeared essential. This was undertaken on the *USNS General Alexander Patch*, full load displacement 22,379 tons (Fig. 2). In addition to inclinometers to measure angular displacements due to pitch and roll, three accelerometers were installed to measure vertical accelerations. One was placed in the center

line in the carpenter's shop about 65 feet from the stem (FP), and the other two were located outboard on each side about 150 feet from the stem (Fig. 3). The accelerometers were developed at the Taylor Model Basin with commercial differential transformers as sensitive elements. The pair amidships were connected electrically so that they could be used to record rolling accelerations or heaving accelerations, although not simultaneously. The signals from the accelerometers were put through suitable amplifier circuits and were recorded by a Brush oscillograph. It was not feasible to record continuously over day-long periods because of the 5-mm-per-second paper feed of the Brush recorder. Spot checks were made at intervals throughout the tests.

The accelerometers were calibrated in gravity units but were converted into feet per second per second units on the data sheets. As the accelerometers were located at only two fore-and-aft positions, it was necessary to estimate the accelerations at other places. The accelerations for the after compartment, C-8, are judged least accurate because of the distance from the nearest accelerometer.

Five hundred and ninety-one passengers aboard the *General Patch* were first observed for seasickness and then engaged in a voluntary trial of the effectiveness of various medications. The findings of this controlled clinical study have been reported elsewhere by Chinn⁵ and by Handford.⁹

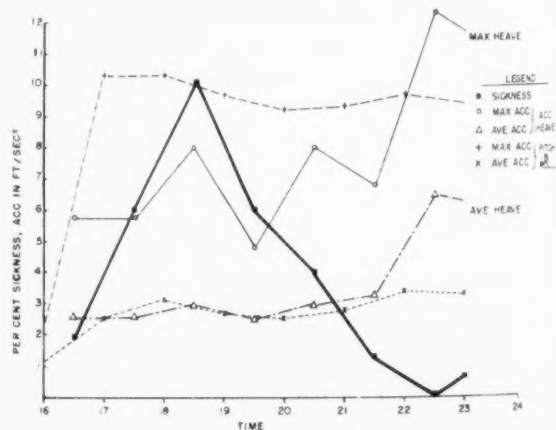


FIG. 6. During the afternoon of Feb. 28, 1951, the ship encountered foul weather. Motions became violent as shown in the diagram. There was marked increase in *mal de mer* concomitant with augmenting accelerations of pitch and roll plus the acceleration of heave. The precipitous drop in the incidence of seasickness after 1900 may be due to the horizontal position assumed by landlubbers (and others) when they "hit the sack." Thus, although maximum heave and average heave were highest at 2230 (10:30 P.M.), no seasickness was reported at that hour, presumably because all passengers were flat on their backs in their bunks.

The highest incidence of seasickness aboard the *Patch* occurred on March 1, 1951, when the maximum linear acceleration of heave reached its peak. At that time pitch was recorded as 4.8 degrees with an average period of 9.2 seconds. Maximum roll 12.5 degrees, periodicity 13.3 seconds) had occurred some six hours earlier and had not induced much seasickness. The nauseating effect of cyclic acceleration and deceleration due to heave was found constant in each of the six compartments studied (C-2, C-3, C-4, C-5, C-7, and C-8) (Fig. 4). The farther the location of a compartment from the ship's center of gravity, the greater the effect of pitch. The highest percentage of seasickness occurred in passengers quartered in bow and stern compartments where the effect of heave and pitch are additive. Thus, the dynamic action of heave, or scend, of a ship up and down in a vertical plane is compounded by pitch and, to some extent, by roll.

In addition to motion and its periodicity, other factors played an important role in the incidence of seasickness among passengers on these two cruises. The position of the body or head posture (with special reference to the labyrinth of the inner ear), the time relationship of motion to meals, the duration of the voyage (individual adaptation to the

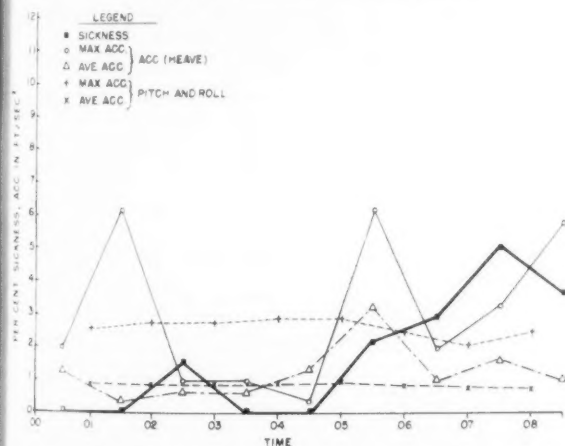


FIG. 7. On March 2, 1951, surface turbulence relented after 0130 and there was little seasickness, except briefly one hour later. But by 5 A.M., the ocean began to get rough again; heave became marked and the percent of seasickness promptly began to rise, even in the presence of decreasing pitch and roll. The rise in the incidence of seasickness almost exactly paralleled the increase in heave between 0430 and 0530, and again during the interval from 0630 to 0730. Although accelerations from pitch and roll remained practically unchanged after 7 A.M., the lines depicting motion sickness and heave are directly comparable, or nearly so, during the final hour (0730-0830), when heave average waned and seasickness decreased correspondingly. It is readily apparent, therefore, that heave is the basic dynamic cause of motion sickness. As heave waxes and wanes, so does the incidence of seasickness.

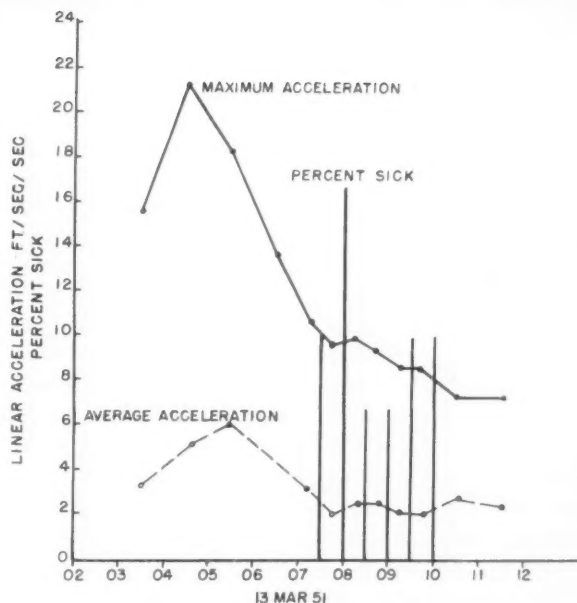


FIG. 8. The disastrous effect of the linear accelerations of roll, pitch, and heave combined with food and ambulation is demonstrated. Maximum motion occurred at 4 A.M. when all but the dog-watch were asleep. Hence at that time there was no reported *mal de mer*. However, there was marked increase in the incidence of seasickness beginning at 7:30 A.M. when the passengers attempted to make their morning toilet and to answer chow call, even though the seas were then moderating appreciably.

sea), previous experience on the ocean—all such factors undoubtedly exerted some influence on the occurrence of *mal de mer* aboard the *USNS General Callan* and *USNS General Patch*. Because any or all of these are variable, it is impossible to state that seasickness is due to a single cause other than the common denominator of dynamic acceleration. It should be emphasized that this was demonstrated with a fixed frequency of motion determined by the natural characteristics of these two ships and within the lower range of accelerations (Figs. 5 to 8).

Of the six motions of a ship, surge, sway, and yaw possess negligible accelerations and contribute to seasickness only when they become synchronized with roll and heave and pitch. Linear accelerations of pitch and roll and heave, alone or in combination, may produce motion sickness. Their nauseating and vertiginous effects are additive and are compounded by surge, sway, and yaw, especially when the rhythmic periodicity of the seas corresponds to the natural frequency of the ship. Under such conditions, the summation of synchronized oscillations (linear accelerations and decelerations in alternate rhythm) may be overpowering.

Every ship tends to oscillate at a particular frequency which is termed natural frequency.⁶ This

depends upon her size and shape and upon the amount and distribution of her loading. When the exciting forces of the sea exactly coincide with a ship's natural frequency, a condition of resonance or synchronism is established. Under such conditions rhythmic synchronous vibrations may be set up which become not only large, uncomfortable, and perilous, but also become hydrodynamically irresistible. Witness the tragic loss of the freighter *SS Flying Enterprise* (Captain Kurt Carlson), which was fractured and sunk by the resonant forces of a winter hurricane in January 1952.

Pitch and roll aboard the *Callan* were measured quantitatively by inclinometers and converted into linear accelerations for a given point at any given instant. No direct proportion could be demonstrated between the linear accelerations of pitch and roll of that ship and the percentage of seasickness among her passengers. Aboard the *Patch* the studies were more complete because accelerometers also were installed and integrated to measure the vertical accelerations of heave. A significant correlation, approaching a direct ratio, was thus obtained. The more this ship heaved, the more her passengers "heaved." Thus, the sum of the linear accelerations of pitch, roll, and heave caused by wind and wave appears to be the common kinetic malefactor in seasickness.

In land vehicles, tangential or radial forces, when rounding a curve, may cause car or train sickness because of the linear component of the angular accelerations thus produced. In the air, horizontal or vertical, tangential or radial, and centrifugal or tumbling forces may be brought to bear simultaneously or in rapid succession. The lines of these forces in an airplane are exerted along and about its three coordinate axes and are independent of the position of the aircraft in space.³ They act in addition to the pull of gravity and induce linear, angular, and cen-

trifugal accelerations. Each type of acceleration can be reduced mathematically to its linear component, and the sum of these linear changes in velocity may induce nausea and vomiting.

Hence, the mechanical or dynamic cause of motion sickness appears to be identical on land, at sea, and in the air. It can be simply stated as the sum of the linear accelerations (and decelerations) along and around the longitudinal, lateral, and vertical axes. Each of the "six degrees of freedom" may thereby contribute to motion sickness. However, the combined effects of surge, sway, and yaw are almost negligible. From the practical viewpoint, motion sickness, when it occurs, is induced by the sum of the linear accelerations of pitch, roll, and heave—and the greatest of these in a seaway is heave.

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More Important Than War

One day during the First World War the celebrated British physicist Rutherford wrote an apology for not attending a meeting that had been called to discuss a war research problem. He stated that he was too busy with experiments in which he seemed to have split the atom. "If this is true," he wrote, "it is far more important than your War."

In talking . . . about the future development of atomic energy I would like to borrow some of Rutherford's perspective. In the midst of a great war this eminent scientist glimpsed the real proportions of that force for human peace and welfare that lies in the energy from the atom—"Far more important than your War." In that thought I find

a strong note of hope, and hope is the virtue in which our national stockpiles are today so low. I trust that our world will put this evaluation "Far more important than War" on the future use of atomic energy.

Such an evaluation will, I believe, come as part of a growing awareness that atomic war because of its overdestructiveness will no longer be a useful means for solving international disputes.

Thomas E. Murray, *Atomic Energy Commission, on the Electric Companies Public Information Program, Chicago, October 22, 1953; quoted in SCIENCE* **119**, 3A (1954).

BOOK REVIEWS

Quackery in the Public Schools. Albert Lynd. Boston: Atlantic-Little, Brown, 1953. ix + 282 pp. \$3.50.

THE author is careful to identify himself as a friend of the public school. Nothing makes him more angry than to be classified loosely among its enemies. He believes in federal aid only for tax-supported schools, the separation of Church and State, higher salaries for teachers, and the development of a basic philosophy of teaching. Intuitively he finds abiding values in the liberal arts. He is against the professor of education and generally refers to him with contempt.

Yet the author himself falls into the trap he sets for the hated "educational bureaucracy." He delights in smear words; he tries to prove his points by quotations that support them. Teachers, he believes, have been deprived of all intellectual freedom, for "quackery in the School of Education will produce quackery in our elementary and secondary classrooms." Since Lynd stoutly maintains that quackery is rampant, if not universal, in schools of education, the reader is faced with a meagerly supported indictment of the teaching profession from top to bottom.

The final outcome is one of frustration on the part of the author, with few ideas as to what is to be done. He makes some good points, however, in citing the silliness of many masters' and doctors' theses offered in schools of education. Even though his illustrations are skewed toward the bad end of the curve (not a single good one is mentioned of the hundreds that might have been), and treated without wit or humor, one cannot escape the feeling that mass production in educational research leads to unhappy results. It puts a premium on the repetitive, the fragmentary, the unimaginative, and it is not very helpful to know that thesis topics in other academic fields are also peculiar.

The book is a long way in time and temper from Henry Adams who, after characterizing the Harvard University he knew as an institution that "taught little, and that little ill," nevertheless went on to praise the open mind of its graduates, "ready to receive knowledge."

Unhappily for his cause, which is not so much to reform the educationists as to get rid of them, this author lets this obsession get the better of his judgment. He states without proof, but it may be accepted for the sake of the argument, that professors of education are ignored by faculties in the liberal arts. Does this mean that college instruction, unlike high school instruction, is effective, purposeful, and on the right track? Actually, the criticisms drawn up against curricula in education are applicable to the numerous subjects in the liberal arts and sciences. The reforms that have been considered necessary at Columbia, Chicago, Harvard, Amherst, and Yale have nothing to do with departments of education.

Lynd approaches writers like Rousseau, Pestalozzi, Dewey, and Kilpatrick with none of the scholar's de-

tachment or thoroughness. This is unfortunate, for in the opinion of the reviewer, he is sound in demanding more of the intellectual, more of the enduring meanings, throughout the educational process. He is rightly suspicious of all that is shallow or trivial; he wants pupils through repeated contact and mental involvement to know other cultures and to get some roots down in the past. But he forgets that this did not happen to any great extent in his day either and he does not mention the increasing mastery of the arts and sciences displayed by large numbers of students in American colleges. To ignore all that while concentrating upon the advice of a well-meaning high school teacher on how to improve the school lunch, is to sell education short.

William H. Kilpatrick, who in Lynd's mind leads the forces of darkness, is himself the product of a liberal arts college with a ten-year apprenticeship as a professor of mathematics! Certainly the Fullers and Bestors are worth quoting, but they, like this book, need the counterpoint of the Spaldings, Cartwrights, and Van Tils.

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The Triumph of the Alphabet. Alfred C. Moorhouse. viii + 223 pp. Illus. + plates. \$4.00. Schuman, New York. 1953.

THIS book by a Senior Lecturer in Classics at the University of Wales, Swansea, is an enlarged version of an earlier one entitled *Writing and the Alphabet* and published in 1946. Some parts have been rewritten, some enlarged, and a new chapter, "The Work of Decipherment," has been added.

The book is well written and the illustrations are well chosen and instructive. Nobody is an expert in all the writings of the world, and we cannot blame the author for some factual errors which have crept into the book.

Moorhouse's contribution to the history of writing will doubtless be well received by scholars of the traditional school. They may find nothing wrong with the author's ideas concerning the origin of the word sign—steeped deeply in the tradition of Horapollon and Athanasius Kircher—such as that the Egyptian words for son and goose are represented by the sign for goose because the latter was "a prized delicacy" or that the "remarkable choice" to express the word for king by the pictogram of a bee "throws light on the ancient Egyptian view of monarchy" (p. 15, similarly for Chinese on pp. 16 and 86). They may even be perfectly satisfied with the statement "that the principles that lie behind writing everywhere are essentially simple ones" (p. xiii). However, I am afraid Moorhouse's work will not serve for scholars with a more progressive approach. They will see no connection between the words for goose and son or bee and king other than a simple phonetic transfer based on the rebus principle. And the present contro-

versy raging around the reviewer's *Study of Writing*, *The Foundations of Grammatology* (1952) shows that the principles that lie behind the origin and evolution of writing are anything but clear and simple.

I. J. GELB

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The University of Chicago

Railroad Engineering. Vol. 1. William W. Hay. New York: Wiley; London: Chapman & Hall, 1953. ix + 483 pp. Illus. + charts. \$7.50.

Railroad Engineering is a textbook written for college courses in railroad engineering. Nevertheless, the material is presented in simple enough form to make interesting informative reading for the average layman.

As a textbook, the book presents very clearly the organization of modern railroads. The economic problems confronted by the engineer in railroad work are clearly stated. The section on motive power is presented in a manner useful to students, in that all the author's derivations are taken from the basic laws of mechanics. The major portion of the book, devoted to roadbed construction and maintenance, has its place in engineering education.

To the "uninitiated railroader" the book is of particular interest. The many problems involved in railroading are explained in clear nontechnical language. The book is very well illustrated and will be enjoyable reading for those interested in the overall story of the American railroads.

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A Survey of Modern Algebra, rev. ed. Garrett Birkhoff and Saunders MacLane. New York: Macmillan, 1953. xi + 472 pp. Illus. \$6.50.

THIS well-known textbook has served, in the last twelve years, to introduce a great many students to the fundamental concepts of modern algebra in an extraordinarily effective way. It does this by discussing examples of mathematical systems or situations already partially familiar to the student, isolating important properties of these as postulates, and deducing some of the consequences of these postulates. These theorems are then applied to some familiar and to some less familiar examples, thus broadening the student's viewpoint without getting him lost in abstractions. The ratio of definitions to theorems and exercises is kept low. Interesting historical references appear in a number of places.

In the revised edition, chapters I to V which treat integers, integral domains, rational numbers, fields, polynomials, real numbers, and complex numbers, have been subjected to minor improvements in the way of additions, omissions, and rearrangements. A section on the Peano postulates for the positive integers has been added to chapter II. The chapter on polynomials has been placed before that on the real numbers, which seems a

better arrangement for pedagogical purposes. In addition there have been included a section on the real roots of real polynomial equations and a paragraph on the trigonometric solution of the cubic equation. To chapter V has been added a brief section giving criteria for all roots of a quadratic or a cubic equation to have positive real part.

In chapter VI on group theory, Section 2, which is an introduction to transformation groups, has been considerably expanded, so as to clarify the basic ideas and notations for the student. The authors here succumb to the prevalent disease of using the preposition "onto" as an adjective.

Chapters VII to X, entitled "Vectors and Vector Spaces," "The Algebra of Matrices," "Linear Groups," and "Determinants and Canonical Forms," respectively, have been subjected to a thorough revision and rearrangement, and have been expanded by a total of 30 pages, so that now they afford a more adequate treatment of this aspect of algebra. Matrices and their row equivalence, linear forms and the notion of dual spaces, have been introduced into chapter VII. Chapter IX contains a more complete treatment of the full linear group and some of its subgroups, and of the invariants of linear, bilinear, and quadratic forms under some of these groups. It closes with a new section on projective geometry. The new chapter X is shorter than the old, because several of the topics have been incorporated into the earlier chapters. However, some new sections on invariant subspaces and canonical forms have been added.

The last five chapters, entitled "Algebra of Classes," "Transfinite Arithmetic," "Rings and Ideals," "Algebraic Number Fields," and "Galois Theory," are little changed from the first edition. They constitute good but brief introductions to their respective topics. The bibliography has been enlarged by the inclusion of quite a number of recent books. The index has also been enlarged, and a number of the lists of exercises have been revised.

The authors are to be congratulated on having improved an already excellent text.

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A Refresher Course in Mathematics. F. J. Gammon. New York: Emerson, 1953. 240 pp. Illus. \$2.95.

THIS compact little book is written primarily for a reader who has already studied the subjects touched upon and wishes to be reminded of fundamental facts of arithmetic, algebra, geometry, trigonometry, and calculus. For such a reader the book contains a wealth of material: selected topics from arithmetic and algebra; essentials of mensurational trigonometry; standard areas, volumes, and physical formulas; a brief treatment of differential and integral calculus. To the definitions of terms and symbols in the text itself are added 32 pages of supplementary formulas and tables.

The author has arranged the contents on a plan he has found successful in his teaching, and he has accompanied the presentation of each mathematical concept

with at least one example. In general, the order seems reasonable, although one may wonder why logarithms and compound interest should be discussed before indices, or an integration formula be introduced prior to the chapter on integration, or even why an arithmetic process for extracting cube roots should appear in this edition. The author's eagerness to reach an example sometimes leads to hasty presentation of a concept, with occasional careless or erroneous statements; the multiplication rule on page 15 and the inequality relating to harmonic progressions on page 61 are cases in point. Occasionally, too, typographical errors creep in. The arrangement of material, the brevity of presentation, and some inaccuracies will not trouble the reader who is being "refreshed," but they make difficulties for the reader who is being introduced to a topic. The author's claim that the book "will be found easy to follow by those making their first acquaintance with mathematics" hardly seems justified.

One small volume that comprises so many topics from a number of branches of elementary mathematics is a boon to the person who seeks to review those subjects quickly. This particular volume has the further advantage of excellent illustrations to give the reader an intuitive understanding of the subjects which they illustrate.

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Infinity. Lillian R. Lieber. New York: Rinehart, 1953. vii + 359 pp. \$5.00.

WITHOUT assuming any technical mathematical knowledge on the part of the reader, the author accomplishes the task of giving a clear and readable presentation of mathematical theories built around the concept of infinity. Such topics as non-euclidean geometry, transfinite numbers, limiting processes, differentiation, and integration are treated. An informality of style is achieved which is extremely effective. Continual emphasis is laid on the naturalness, beauty, and power of mathematical methods. The author intermingles with the mathematical discussion occasional pointed remarks challenging the "practical" man to emulate the courage and intellectual honesty of the creative mathematician. The drawings are unusual and interesting.

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The Philosophy of Nature. Andrew G. Van Melsen. Pittsburgh, Pa.: Duquesne University Press, 1953. xii + 253 pp. \$4.50, cloth; \$3.75, paper.

Science in Synthesis. William H. Kane *et al.* River Forest, Ill.: Dominican House of Studies, 1953. xii + 289 pp. \$3.50.

IN the first of these two books, Andrew G. Van Melsen, professor of the philosophy of nature and of science at the Charlemagne University of Nijmegen,

explores simultaneously the respective areas of application of what he calls the philosophy of nature, as well as the philosophy of science and natural science itself, in an attempt to show the limitations and the relative strength of each. In general, Professor Van Melsen is concerned not so much with nature as with "human knowledge of nature." In this sense, he primarily addresses himself to the professional philosopher, rather than to the scientist, because his aim seems to be more to discuss the epistemological problem of what we know and how we know it, rather than to attempt a critique of the methods of science as actually practiced. In a bird's-eye view of the "history of the study of nature," the author would have us believe that for twenty centuries Aristotle was "the guide of the intellectual and scientific world. Studying the phenomena of nature has amounted to studying the works of Aristotle." It is implied that this was true throughout the Hellenistic, Arabian, and medieval periods. Unfortunately, this view cannot pass the muster of historical scholarship; it fully ignores the developments in Hellenistic exact science, which were influenced in part by Babylonian mathematics, and it discounts completely the influence of Archimedes, and other non-Aristotelian scientists of antiquity. It may also be observed that the author limits his discussion entirely to the physical sciences, as most philosophers of science do at the present time, whereas one would logically expect a discussion of the "philosophy of nature," whether historical or analytical, to include materials concerning the biological sciences.

Science and Synthesis is a report on a five-week seminar held at the Albertus Magnus Lyceum for Natural Science. Each week was devoted to a single problem: physics, chemistry, biology, psychology, and summary. The report is offered "for those interested in seeing a frank and dialectical approach to the problem of the integration of the physical and natural sciences." It is observed that "the dialectical approach seems at this stage of the problem to be the most appropriate," and it is hoped that the "broad and objective basis for future discussions" will "bear fruit in due season." An outside observer cannot help but be interested in the conflict of opinions that arose. At one point, "it was becoming increasingly clear to all that modern physics and chemistry employ principles of a hypothetical character (although, as had been seen, these may be 'established' and contain a core of certain truths)," but "the Aristotelian-trained participants had so frequently referred to the logical requirements for a science in the 'strict sense' that it became necessary to devote an evening of discussion to 'a lecture on the Aristotelian concept of science.'" It would seem that this volume, too, deals primarily with epistemological problems in science, attempting to establish a critique of the foundations of scientific knowledge; no attempt is made to see how science as practiced can be made more fruitful and productive. It may be observed that it is not customary today to use in scientific discussion, as such, the expression "certain truths."

These seminar reports are illustrative of the continual longing of man to integrate into one simple and self-

consistent system our knowledge of the external world and the creatures who inhabit it, usually presented from many disparate points of view. Not all readers will be convinced "that it is of genuine importance for contemporary science to understand the naturalistic viewpoint of the Aristotelian tradition, particular as it appears in the fundamental physics and the general biology of Aristotle." It is somewhat doubtful as to whether an "acquaintance with recent research in the history of science" shows that "the whole scientific tradition centers around repeated renewals of interest in the problems raised by Aristotle." This position, similar to that of Van Melsen, is certainly a little extreme, just as is the opposite position, that Aristotle's very existence is the worst thing that ever happened to science. It will be interesting to see, presumably in future volumes based on other seminars, how far a neo-Aristotelian point of view can effect any genuine integration of the natural sciences, or contribute a point of view that will be in any sense essential to the advancement of science, to our understanding of the nature of science itself, or to the relation of scientific knowledge to knowledge obtained in any other fashion.

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In Spite of. John Cowper Powys. New York: Philosophical Library, 1953. 312 pp. \$5.00.

DOUBTLESS there is a place for "inspirational" books, for volumes of advice on how to live and bear it. Life being what it is, too often for too many, only the most mean-spirited would begrudge these lay pastors-cum-psychotherapy a place on the publishers' lists. Since the philosophical life is the examined life, John Cowper Powys rightly contends that every man is entitled to his own philosophy, in spite of the experts in physics and metaphysics. If this reviewer casts a cold eye upon the author's essay at a philosophy of life, it is from neither coldness of heart nor intellectual snobbery.

The author, a novelist who is now over eighty, is a man of good will, a materialist and individualist in the nineteenth-century fashion. Most educated people will sympathize with his revolt against the tyrannizing superstitions, religious orthodoxies, social strictures, and prejudices that drain from life its savour and zest. Powys' philosophy of life is in the tradition of Walter Pater, the aesthete, rather than of Thomas Carlyle or even of John Stuart Mill. His basic principle is "to force ourselves to enjoy life," in spite of experts, loneliness, pride, orthodoxy and heresy, madness, class, insecurity, belief, and other people. A chapter is devoted to each of these obstacles to the enjoyment of life.

"Not to love, not to hate, not to understand, not to worship, not to interpret, not explain, simply and solely to enjoy; this is the secret of secrets." Powys' philosophy of life is thus an aestheticism, the aestheticism of all philosophies of "experience." The ugly and the beautiful, the good and the evil, the wearisome and the stimulating, all, and all indifferently, are grist for the mill, for that highest value, the moment of experience itself.

Is "enjoyment," the qualitative experience, in fact the purpose of life? The scientist, who finds his direction and purpose not in raw experience but in the search for its explanation, may well wonder. He seeks to understand; the enjoyment is derivative. For "everyman," be he scientist or plain man, are ugliness and wickedness to be "enjoyed"—or combatted?

Most revealingly, the real villain is not any of the items in the catalog of "in spite of's." Rather, the villain is love, not merely the abstract New Testament love, but also the ordinary love of one human being for another. For love, according to the author, not only contains the germ of hate, but also inhibits the ability to see other people as "dolls," to imperturbably detach oneself, kindly and considerately, from their miseries and fears. Thus, his ideal of "enjoyment" resolves into a pallid grasping at experience, emotionally uninvolved and morally irresponsible. His style is commensurate with his thought; at once exclamatory, coy, and insufferably patronizing, it renders his message for the millions even more unpalatable to the literate.

MAY BRODBECK

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The Interpersonal Theory of Psychiatry. Harry Stack Sullivan. New York: Norton, 1953. xviii + 393 pp. \$5.00.

THIS book is based mainly on a series of lectures that Sullivan gave in the Washington School of Psychiatry in the winter of 1946-1947, and represents, according to the editors, "the last complete statement which Sullivan made of his conceptions of psychiatry." The book—let it be said at once, although the statement almost goes without saying to those familiar with Sullivan's work—is a major contribution to theoretic psychiatry, and will most certainly enhance Sullivan's reputation as one of the most original and gifted psychiatrists this country has produced.

Early in the book Sullivan points out the inadequacy of a purely descriptive approach to psychiatry, finding it—like Freud before him, and many others—not very meaningful or clinically useful. By contrast, Sullivan "attempts to explain serious mental disorders," and to produce a kind of psychiatry that will be of "some use in living in general"—at least, it may be hoped, not less useful than "scientifically" untutored common sense. How to communicate such a theory has, he confesses, "puzzled and harassed" him for "a great many years," but he finally decided that "the only approach is by the developmental route."

One motive behind this book is clearly suggested by Sullivan's statement: "I don't believe many psychiatrists have a very good theoretic framework for thinking about difficulties in living, their origin, their dependable manifestations, or their fairly certain improvements." He works hard in this book to supply such a theoretic framework. Some clinical psychiatrists may debate the practical value of this theory in working with patients. Some child psychologists may doubt that

he has enough facts of observation to support the highly inferential discussions of personality development. Some logicians may wonder as to how "operational" Sullivan's definitions of basic terms really are and how testable many of his conclusions are by reference to reliably identifiable facts, and more specifically, about his tendency to offer as generalizations or "theorems" having predictive value only slightly disguised tautologies. But, in spite of these questions regarding the logical rigor and scientific adequacy of his theoretic formulations, the book as a whole is a very impressive performance, full of the wisdom of ripe experience and replete with insights into many obscure but basically important matters. In a field where professional jargon and superficial clichés so often function as irritating substitutes for real thought about the nature and causes and treatment of mental disorders, it is a stimulating and gratifying experience, of a high intellectual order, to read these carefully thought out and circumspectly worded lectures by such a candid and searching mind. For this he deserves the gratitude of all serious students of psychiatry, and, more generally, of all those who agree with Pope about the proper study of mankind.

JOHN R. REID

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Groups in Harmony and Tension. Muzafer Sherif and Carolyn W. Sherif. xii + 316 pp. Illus. + plates. \$3.50. Harper, New York. 1953.

WRITERS on social psychology may be roughly divided into analysts and pragmatists. The pragmatists, even if aware of the difficulties inherent in events spanning the borders of psychology, biology, and the sociological and anthropological domains, remain undaunted by the problem of how to study such events most effectively. They proceed at once to work in one of two practical directions. If they are quantitatively motivated they emphasize statistical variation, contrive tests, and measure the results of applying them. Or, if they are profoundly impressed by the need to improve human circumstances they seize upon any sort of manipulation to achieve reforms.

The second type of procedure characterizes the present book. On the first page we read: "Today, it will be hardly an exaggerated statement to say that the balance of the fate of the human race hangs primarily on the course of developments in the area of intergroup relations on both national and international levels." Sensitive to the increased participation of peoples of every class and level in intergroup behavior, the authors point out the role of modern transportation and communication in bringing hitherto isolated lands and populations into close interdependence.

Realizing the enormity of the problem to control intergroup harmonies and tensions, they propose an integration of studies, an interdisciplinary approach. Psychologists must cooperate with students of history, economics, politics, biology, sociology, and anthropology.

In the sequel, however, the authors proceed as though the social psychologist can dominate the scene. They even regard an 18-day experiment on group attitude and stereotype formation among each of two sets of 12 boys at a summer camp as a scientific test and verification of basic principles.

The authors justify their reduction of the complex problems of intergroup relations to attitude formation on the basis of their belief that all groups can be reduced to psychological reference groups. These are groups to which individuals relate themselves or aspire to do so. The reference-group concept "is a generic one which can be used in dealing with any group and its relation to any other group." Obviously what crops out here is an underlying mentalistic type of psychology which levels and intermixes every variety of event.

Such oversimplification and reduction suggest the vanishing line between pragmatists and analysts. Both the analysts who refrain from what they deem trivial manipulation and the pragmatists who resort to precipitous procedures must construct propositions derived from fairly distant contacts with complex events. To the credit of the present writers it must be said that despite their pathetic juxtaposition of national (politics, economics) and international relations (war and peace) with the behavior of small groups of boys, they go along with competent analysts in condemning the racist approach, the theory of invariable human nature, as well as the attempt to apply principles of animal behavior to human groups.

J. R. KANTOR

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Indiana University

Nationalism and Social Communication. Karl W. Deutsch. Boston: Technology Press, Massachusetts Institute of Technology; New York: Wiley; London: Chapman & Hall, 1953. x + 292 pp. Illus. \$5.00.

INDUBITABLY it has called for courage of a high order to undertake the task represented by this book—that of presenting a synthetic study of human beings in their collective relationships. The fearlessness of the author in crossing the sacred boundaries of a number of the traditional academic disciplines in an effort to overtake truth and so to arrive at an understanding of it is one of the most noteworthy features of a decidedly noteworthy book. For the degree of success with which he has accomplished a Herculean task, for the extent to which he has found it possible to be definitive in an area of human behavior where relatively little is definitive, Professor Deutsch deserves the highest approbation.

This is not to say that, with all of its crude amassing of evidence relating to nationalism, the author has set forth conclusions valid beyond challenge. Rather, he has opened up new avenues for inquiry and debate in a wide field in which, as he suggests in his final summary, the last word is not likely to be said in our time. Few features of human society are more complex in origin or more disparate in manifestation than that of national sentiment. It may even be doubted that a manifestation that melds so much of the background of the

race with the traits of the individual ever can be altogether adequately described. This is implicit in the many "views of nationalism and nationality in the past" which are brought together in the first chapter. These citations appear to have by-passed the circumstance that possibly the strongest single influence leading to group integration is an almost universal need for some kind of security. Human beings unite, consciously or unconsciously, I believe, primarily *against* some alien force. The very concept of nationality implies *other* nationalities.

Lest an attempt briefly to review a notable book degenerate into an airing of pet ideas or petty criticisms, however, let it be noted that *Nationalism and Social Communication* is a remarkably comprehensive piece of work. In its nine chapters, dealing with such topics as sovereignty and politics, national assimilation or differentiation, unity or diversity, and national consciousness and will, it presents a well-rounded and, if not a scientific, at least a social scientific, analysis of the phenomenon of nationalism. At a time when the survival of civilization hinges on the workings of nationalistic forces, the book provides an essential tool for the study and understanding of contemporary problems.

HALFORD L. HOSKINS

Library of Congress
Washington, D. C.

Culture. A. L. Kroeber and Clyde Kluckhohn. Cambridge, Mass.: Peabody Museum, Harvard University Press, 1952. viii + 223 pp. \$5.25.

THE anthropological concept of culture is one of the most important concepts in the social sciences today. It was developed by German scholars over a century ago. The great British anthropologist, Edward Burnet Tylor (1832-1917), took it over from the Germans, gave it definition, introduced it as a technical term into English usage, and established it as a basic concept of anthropology. Since then it has spread to other disciplines: to history, sociology, psychology, and others. In recent years it has come to be used rather generally by laymen, even appearing in comic strips!

Thirty years or so ago most anthropologists knew, or thought they knew, what they meant by culture; at any rate, they experienced no difficulties with the concept. And most of them, I believe, employed the term approximately as Tylor defined it: "Culture or Civilization," he said, "is that complex whole which includes knowledge, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" (first sentence of *Primitive Culture*, 1871). Today it is different. Technical literature in several disciplines abounds with conceptions and definitions of culture: it is "learned behavior"; it is not behavior at all but an "abstraction from behavior"; it is "intangible," a "logical construct"; it is a "psychic defense system," a "stream of ideas"; it "consists of all ideas concerning human beings which have been communicated to one's mind and of which one is conscious," and so on. One anthropologist, at least, has even ques-

tioned "the reality" of culture. Many may agree that culture is a basic and important concept, but there is little consensus as to definition and usage.

The work under review begins with a history of the word culture. Next, definitions of culture are presented in Part II. The "nature of culture" and its relationship to psychology, language, individuals, and society are discussed in Part III. In Part IV, Summary and Conclusions, the authors discuss problems raised by the number and variety of conceptions of culture. They define some of the issues and attempt to clarify them. Finally, they offer their own conception of culture.

The general reader will be impressed by the number and diversity of conceptions of culture extant. Some, no doubt, will be bewildered or appalled by the vista of chaos and confusion presented, and wonder why so much fuss is made over a concept about which there is so little agreement. But the concept of culture, we venture to predict, is here to stay. And eventually some consensus of meaning and usage will emerge. It was to help to reach this goal that Kroeber and Kluckhohn undertook this study. They have made a noteworthy contribution. But most readers will probably agree with the authors, and with the present reviewer, that "as yet we have no full [or adequate, L. A. W.] theory of culture" (p. 181).

LESLIE A. WHITE

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Culture Change. An Analysis and Bibliography of Anthropological Sources to 1952. Felix M. Keesing. Stanford: Stanford University Press; London, Bombay, and Karachi: Oxford University Press, 1953. ix + 242 pp. \$4.00.

WITH the tremendous technological development of the last few decades, and when everyone is made to realize that we are verging on a possible new atomic age, the science of ethnology repeatedly exhibits signs of maturity. Man looks at himself and his culture—the ethnologist takes stock of his past efforts. The world is shrinking so that even the lonely Indian hunter of the Great Slave Lake area, the native of the Congo tropical rain forest, and the roamer of the Australian desert is directly affected in the scramble for radioactive ores and the power that they will bring to those who can harness it. Modern man has been aware of progress, but with his expanding knowledge of the peoples of the far corners of the earth, and on contemplating his own history and cultural legacy, he begins to wonder about the future. This is reflected in the ethnologist's turning more and more from the historic and descriptive approach to a scientific one in which he tries to study the factors affecting culture change, to formulate rules or laws in order to be able to predict what will happen, and perhaps to direct the changes of the future in order to become truly the master of his destiny.

Professor Keesing's volume, *Culture Change*, is another step in the direction of utilizing ethnological

data to develop a science of culture. The book comprises the first of a series of studies on the dynamics of culture carried on within the Department of Sociology and Anthropology of Stanford University. It is written for the professional ethnologist with the purpose of furnishing a general frame of reference for future work. Approximately half of the book, 94 pages, is devoted to an analytical survey, a chronological listing of works with brief annotations, and the rest of the book to a bibliography the items of which are grouped by decades to 1940 and, following that date, by years.

The earlier works in ethnology, especially those written in languages other than English, are perhaps treated too summarily, a circumstance that could have been avoided by consulting histories of anthropology such as Wilhelm E. Mühlmann's *Geschichte der Anthropologie* (1948), which covers this area more adequately. The later periods are well covered, and the analysis of the most recent writings, notably those published since the appearance of Lowie's *History of Ethnological Theory* (1937), make Keesing's volume indispensable to all who teach or do research in the field of cultural anthropology.

GEORG K. NEUMANN

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Volcanoes as Landscape Forms, 1st ed. rev. C. A. Cotton.
New York: Wiley, 1952. iv + 416 pp. Illus. \$9.00.

THE present so-called revised edition of *Volcanoes as Landscape Forms* carries the date 1952, the imprimatur of John Wiley & Sons, and a statement by the author that it is a revised edition. Actually, however, hardly more than fifty words have been changed from the New Zealand edition of 1942, and the present printing amounts to merely a reprint of that edition. The only change is the elimination of a single half-tone; the first and last words of every paragraph are identical with those in the first printing, and most pages are word for word the same. The only exceptions to this are the shifting of lines made necessary by the deletion of the half-tone mentioned. It is still a good book, although now a bit dated.

JAMES GILLULY

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America's Ancient Civilizations. A. Hyatt Verrill and Ruth Verrill. xvi + 334 pp. Illus. + plates. \$5.00. Putnam's, New York. 1953.

THERE is no reason for reviewing this book in THE SCIENTIFIC MONTHLY except to issue a warning about its essentially unsatisfactory nature. If the volume had merit as a literary production, then its publication might be deemed justifiable. As a contribution either to the Indian civilizations of the New World or their connections with the Old, the book will not be welcomed by the archaeologists. It is misleading for the general public.

The tenor of the book is expressed in the introduction, where Mr. Verrill states that *America's Ancient Civilizations* has been based largely on his own researches and first-hand knowledge, while the connections of America's high civilizations with Sumeria, and particularly the beginnings of Peruvian culture, are the by-product of Mrs. Verrill's studies of ancient Asiatic civilizations and dynasties. Mr. Verrill calls upon the general reader to decide whether the authors' interpretations of American prehistory or those of archaeologists, usually unnamed by the Verrills, are correct. There is no point in attempting a critical review, since it would imply that the authors possess a higher degree of scholarship and scientific responsibility than they demonstrate in this work.

JAMES B. GRIFFIN

Museum of Anthropology
University of Michigan

Fossil Plants of the Florissant Beds, Colorado. Harry D. MacGinitie. Washington, D. C.: Carnegie Institution, 1953. iii + 198 pp. Illus. + plates. \$5.25, paper; \$5.75, cloth.

THE plant impressions in the Tertiary lake shales at Florissant, in central Colorado, constitute one of the most widely known of fossil floras. The literature pertaining to them is extensive and scattered, and with the exception of Lesquereux's original account in 1883, this recent study is the only comprehensive one ever made and is the first to use modern techniques in its interpretation.

The plant-bearing shales at Florissant are thinly bedded lake deposits that consist mainly of pumice and volcanic dust. They occur in the lower part of a series of volcanic tuffs, conglomeratic arkoses, and rhyolites that were spread over the eroded surface of the pre-Cambrian Pikes Peak granite. Reinvestigation of the geologic features shows that these deposits do not conform to the boundaries of an ancient lake, as formerly supposed, but owe their present spread to faulting, folding, and erosion of beds that once covered a larger area.

MacGinitie recognizes 114 species that can be classified, which are distributed among 84 genera and 44 families. The Leguminosae is the largest family, followed by the Rosaceae, Sapindaceae, and Anacardiaceae. The Pinaceae, Ulmaceae, Lauraceae, and Saxifragaceae are also well represented. The most prevalent member of the flora, from the standpoint of the number of specimens counted, is *Fagopsis longifolia*, which makes up 30% of the total. Found only at Florissant, it belongs to the Betulaceae, instead of the Fagaceae where it was originally placed. Some genera that no longer live in North America in the native state are *Lomatia*, *Zelkova*, *Ailanthus*, and *Koeleruteria*. Then *Daphne* and *Trochilia* are recorded for the first time in the American Tertiary and *Cotinus* for the first time in the Tertiary anywhere. *Platanus* is represented by one leaf and *Tilia* by three.

Apparently the flora grew at an elevation between 1000 and 3000 feet. The climate seems to have been warm temperate with rainfall sufficient to support

copious forest growth only along stream courses. On higher grounds pines and evergreen oaks dominated open scrub forests. There is no evidence for the existence of extensive grasslands, but grasses did cover some small dry areas.

The author concludes that the flora is of lower Oligocene age. Of other western Tertiary floras, it is closest to the Middle Eocene Green River flora although it has several elements in common with the Bridge Creek flora of the Upper Oligocene or early Miocene.

C. A. ARNOLD

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Evolution in Action. Julian Huxley. New York: Harper, 1953. x + 182 pp. Illus. \$2.75.

STUDENTS of evolutionary process, who have read Julian Huxley's magnum opus, *Evolution, the Modern Synthesis*, will not find much in this small volume that they have not heard the author say already; but then, the book is not addressed to them. These chapters are the Patten Lectures delivered by the author to a general audience at Indiana University in 1950 and 1951. As such, they are admirable, clearly and simply setting forth what is known at the present day about The Process of Evolution, How Natural Selection Works, Biological Improvement, The Development of Mental Activity, and The Path of Biological Progress. The point of view is that of a biologist rather than a paleontologist, and the book thus supplements admirably that other recent series of lectures delivered under similar auspices, G. G. Simpson's *The Meaning of Evolution*. Huxley and Simpson are in fundamental agreement as to the major evolutionary principles. The parallel between them goes even further, for both are preoccupied with questions that are, at least in part, philosophical—questions about the reality of progress in evolution, about the place of man in nature, about the role of man as guide and director of the future course of animal and plant, as well as human, evolution upon this planet. Nor are their answers, so far as these may be given, too unlike.

Huxley has made an interesting distinction on this occasion between biological improvement and biological progress. He points out that the deployment of life forms into all the available niches of the environment, the "adaptive radiation" of an older vocabulary, tends to come to a stop, to become stabilized or to become extinct. Even advances in efficiency often reach a limit inherent in the nature of the mechanism which is being improved. Progress, on the other hand, must keep within it the seeds of further advance, must permit or facilitate further improvement. "For specialization and detailed adaptation the standard is the survival of a particular line of living substance. For advance, the standard is the general efficiency of biological machinery. For progress, the standard is the process of improvement itself." Measured by these criteria, one can easily appreciate how slender is the hope for biological progress in nature, can easily meas-

ure the overwhelming odds in favor of evolving into some dead end.

It is Huxley's principal belief that the development of mental activity offers an escape from this fate. Mind is the chief weapon wherewith life can flexibly adjust itself to changing situations without too great a need for these rigid adaptations of structure and physiology that can survive only within a prescribed and narrow environment. By means of mind, adaptability may supercede adaptation. The transition from this theme to the concluding one is natural, almost inevitable, in its logic. Man exemplifies more than any other species of animal the powers of mind. Through disciplined mental activity, in the form of science, he has at length grasped the nature of evolutionary forces and has learned how to control them. "In the light of evolutionary biology man can now see himself as the sole agent of further evolutionary advance on this planet, and one of the few possible instruments of progress in the universe at large." Science must thus concern itself with values, for one of many roads must be chosen. Even to make no choice, in the light of evolutionary knowledge, is ineluctably to make a certain choice. Man must assume, along with his new insight and his new powers, a fearful responsibility.

It is amazing that people can listen and remain unmoved, can go away and resume the life of yesterday. Upon this generation are in truth bestowed the keys of life and death—the power to destroy all life in an inferno of atomic destruction, and the power to create life of a higher, and we hope also nobler, sort than the old. Men are afraid, but slow to change. Even youth is educated in old, set patterns, and fails to heed the challenge of human destiny.

BENTLEY GLASS

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Elements of Heat Treatment. G. W. Enos and W. E. Fontaine. New York: Wiley, 1953. 286 pp. Illus. \$5.00.

THE purpose of this book is to set down in simple straightforward language the basic fundamental theory involved in the heat treatment of metals for those not specifically trained in metallurgy. Although the book was written primarily as a textbook for freshman engineering students, it will provide interesting and valuable reading for engineers and others who feel that their understanding of the why's and wherefore's of the properties and behavior of metals is inadequate for our modern industrial world where the right metal for the right job is so important. The cartoon-type illustrations are effective in clarifying and stimulating interest in the book.

The authors have had extensive experience in teaching and in industry. By simple language and generous use of photographs and figures they provide knowledge and understanding of the basic fundamental principles underlying the properties of metals and alloys, and their modification by heat treatment to obtain desired mechanical characteristics. The combination of equilibrium

diagrams and photomicrographs, showing characteristic crystal structures plus simple, lucid descriptions of the heat treating process involved—annealing, hardening, tempering, and normalizing—makes the “why” as well as the “how” of these processes easy to understand. The major emphasis is upon steel alloys and their properties, with some discussion of the effects of casting, forging, welding, and similar processes. Common nonferrous alloys are discussed briefly. No references to current literature are cited and advanced topics in metallurgy are avoided, but a wealth of valuable information is presented.

The book is designed for the nonspecialist interested in improving his working knowledge of metals and alloys, whether he be an employee without formal training in a commercial plant utilizing heat treating processes, or an engineer who desires to review and bring up to date his college metallurgy. Anyone interested in knowing more about metals and alloys and why attention to composition and heat treatment is important will find this book profitable and interesting reading.

GEORGE G. LAMB

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The Whooping Crane. Robert Porter Allen. New York: National Audubon Society, 1952. xxvi + 246 pp. Illus. \$3.00.

THE National Audubon Society, like many other conservation organizations, recognizes that the only sound basis for policies governing the conservation of wildlife resources are the facts obtained through scientific research. It also acts to obtain those facts. The present book is Research Report No. 3 of the Society, and its subject, the whooping crane, is “the second rarest living species of North American birds.” It is on the verge of extinction. Only wise management based on a thorough knowledge of the species can hope to save it. The present investigation was a joint undertaking with the U.S. Fish and Wildlife Service of the Department of Interior, which is also responsible for the management practices that were applied on the wintering range. The book is divided into eight parts as follows: distribution; abundance; migration; food habits; winter life; the breeding cycle; molts, plumages, and anatomy; and survival, protection, and conservation. Each topic is not equally treated and, as one might expect in a work of this type, the parts on distribution (past and present) and abundance comprise about one-third of the book. The section on molts, plumages, and anatomy comprises only five pages, as the anatomical materials are still under investigation.

From an original distribution (prior to 1860) which covered most of the North American continent, the whooping crane is now found in winter only on the Arkansas Refuge (Blackjack Peninsula) and nearby Matagorda and St. Joseph Islands, on the Texas coast. These birds migrate through Oklahoma, Kansas, Nebraska, and the Dakotas into Canada. About one-half of the group, comprising nonbreeding individuals, scat-

ters out from the Manitoba-Saskatchewan line to western Alberta during the summer months. The remainder continue to their nesting grounds where they rear an average of four young annually. The location of the present breeding area is unknown.

It is estimated that the population around 1860 to 1870 may have been one thousand three hundred to one thousand four hundred birds. There is evidence that the whooping crane was never observed in large numbers even one hundred or more years ago. The “myth of superabundance” may have arisen from a misinterpretation of some of the early writings on the status of the species. The present population (1950) consists of about thirty-five individuals, two of which are captive birds. Analysis of population trends for nine years (1940–1949) indicates that a gain of only four can be expected in the next decade. Losses will be about thirty-six birds, and only fifty percent of these will probably be attributable to natural causes.

After a careful consideration of the record and the present facts, Allen makes a number of specific recommendations for the protection and conservation of the whooping crane. He recognizes, however, that nature’s “goal” with respect to this species cannot be disregarded and may actually be contrary to man’s. Nevertheless, he believes that for man’s welfare and with direct action by man, it may be possible to stave off extinction. The recommendations consist essentially of providing complete protection for all wintering and migrating birds, education of the public with respect to the status of whooping crane and its role in the survival of the species, and continued study of the biology of the species, including the possibility of artificial propagation and, particularly, population trends.

The author and the two supporting organizations have placed in the record many facts about a rare North American bird. They have also provided a sound basis for the formulation of effective measures of protection and conservation. Whether these measures are carried out will depend on the efforts of many people.

The book is well illustrated. The minor weaknesses do not detract from its primary purpose, and it is highly recommended to those interested in birds and in conservation.

ALBERT WOLFSON

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Northwestern University

Parental Care and Its Evolution in Birds. S. Charles Kendeigh. Urbana: University of Illinois Press, 1952. x + 356 pp. Illus. \$4.00, paper; \$5.00, cloth.

AMONG animals, two groups stand out because of their unique trait of warm-bloodedness—the birds and the mammals. In these same groups we have another well-developed trait—care of the young. It reaches its highest development in birds and mammals and has undoubtedly been an important factor in their successful evolution. Although both groups are well suited to studies of parental care, birds would seem to be the subject of choice. Some of the reasons for this

are the ease with which observations can be made in many different species, the fact that many observations can be recorded automatically, and the occurrence of diverse behavior patterns, which permit a consideration of the evolution of parental care.

The book consists essentially of two parts. The first part (chaps. 1-4; pp. 1-172) deals almost entirely with only one aspect of parental care—attentive behavior. About half of this material is devoted to one species, the house wren (*Troglodytes aëdon*) which has been studied intensively by Kendeigh and his collaborators. The remainder considers a miscellaneous group of 19 species and includes data available in the literature. The second part (chap. 5, pp. 172-302) consists of a summary of information on breeding activities and behavior in the many orders and families of birds. On the basis of this phylogenetic survey, Kendeigh discusses the evolution of parental care. The final chapters (6 and 7) present an extensive bibliography, which is also an author index, and an index to the species mentioned in the text.

Although the book suffers somewhat from prolixity and lack of attention to some fine details, the author has performed a real service by bringing together, correlating, and synthesizing the scattered and extensive literature on parental care in birds, and he has made an important contribution to avian biology through his own extensive studies.

ALBERT WOLFSON

Department of Biological Sciences
Northwestern University

Great Men of Science. Philipp Lenard. New York: British Book Centre, 1950. xix + 389 pp. Plates. \$3.25.

THE distant goals of science, says Lenard, "will be approached by natures of a kind as unprejudiced as Mendel. They will have to be men of science capable of assimilating facts of every kind . . . and then working them over like Darwin and Mendel, in seclusion. . . ." Such remarks on the importance of solitary and independent work run like a leitmotif through this collection of sixty-five biographies of scientists, all of whom, except for the two mentioned above, are physicists or chemists. Nobel laureate Lenard castigates the modern emphasis on technical achievements and showpieces in physics, accompanied as it is by too little attention to simple insights. A humanist, surveying a million-dollar calculating machine or atom smasher surrounded by its swarm of Ph.D.-sporting hetaerae under the procurement of a "big operator," cannot but sympathize with the author. He is in love with a world that, for better or worse, seems to be going or gone.

This is an old-fashioned book in other respects as well. The biographies, which appear to be assembled lecture notes, surely have undergone little or no revision since the first printing in 1933. Wöhler, rather than Kolbe, is given credit for the first total synthesis of an organic compound; the ignorance of Mendel's work is still ascribed to its publication in a "hardly accessible place." Despite the conclusions necessitated by the im-

mense labors of science historians like Sarton, ancient and medieval science are represented as being almost nonexistent. Lenard says that the birth of modern science necessarily required the activity of the "new man from the North, the only home on earth of the seekers and bringers of light." When, in discussing biological problems, our physicist turns his eyes from the past toward the future he scarcely earns more of our confidence as he replaces vitalism by *spiritualism*!

In spite of such lapses, however, one feels that Lenard's lectures in physics were probably more enriched than the average with historical and humanistic elements. But since so many of his biographical side lights are standard encyclopedia material, it is natural to wonder if, and in what sense, the publication of this book was called for.

GARRETT HARDIN

Santa Barbara College
University of California

Modern Nationalities. Florian Znaniecki. Urbana: University of Illinois Press, 1952. xvi + 196 pp. \$3.95.

THIS volume is a survey from a sociological point of view of the cultural factors that have operated historically in the growth of nationalism in the western world, and offers the thesis that "national culture societies" rather than an organized political state are the viable solidary social units that are the most important to understand.

Znaniecki distinguishes four types of society: tribal, political, ecclesiastical, and national culture societies. It is the last that is the subject of this volume. Although there are several references to India, Japan, China, and the Near East, the bulk of his material is drawn from western Europe, and the growth of modern nationalism in Europe from the Renaissance to the present day. In view of the history of Poland from 1795 to 1920, of the peoples of the Balkans under the Ottoman and Austro-Hungarian Empires, it is quite clear that each of the ethnic groups possessing distinctive cultures and societies succeeded in perpetuating their cultures and retaining their identities under foreign political organizations.

Tracing the spread of the vernacular languages, the publication of historical, philosophical, and later scientific books in these languages instead of Latin, he finds four dominant ideas promulgated by the ideologues: the ideals of national unification, national progress, a national mission, and national independence. The roles of musicians, artists, and economic leaders in providing other symbols and themes that add to and diffuse a national tradition are discussed. He then outlines the major groups and institutions that function to increase the social solidarity of nationalities from literary associations to universities.

Two chapters are devoted to illustrations of the sources of conflicts between nationalities and the growth of cooperation in the fields of importation and exchange of scholars, scientists, and artists. His final chapter speculates about the possibilities of a world society and culture, outlines important projects looking in this direction

by UNESCO, and points out the need for systematic research in the socio-cultural field, and for the spread of this knowledge to the political decision makers.

Until the twentieth century nationalism was largely a European phenomenon. Today, in the Near and Middle East, Southeast Asia, in India, and elsewhere there are political movements that are usually described as "nationalism." This reviewer suspects that systematic research in these areas would reveal both different content and configuration in the complex, which is partly obscured by referring to it as nationalism. The tendency to interpret human culture in terms of the European tradition is a difficult one to avoid, since the languages and materials in non-European languages are not readily available in most western scholars. Znaniecki has outlined the problem in its historical growth in the West. Let us hope that some of his students will carry their researches into other areas of the world.

EDWARD A. KENNARD

Foreign Service Institute
Department of State
Washington, D. C.

Hebrew Marriage. David R. Mace. New York: The Philosophical Library, 1953. xv+271 pp. \$6.00.

THIS excellent study of marriage and family life among the ancient Hebrews proves that the Old Testament is an inexhaustible source, not only of inspiration but also of knowledge. The ancient Hebrews recorded their own ethnology. The author came to this task with the comparative view derived from anthropology, and the urgency of a marriage counsellor to understand an institution now in trouble. The record of what he learns makes an important book which is highly readable.

It becomes clear that the strong family feeling characteristic of Jewish culture has firm roots in the Hebrew family that was essentially monogamous. Parents committed themselves to each other and to their children; far from being the mere chattel sometimes pictured, the mistress of the house was "more like a queen" in it. The importance to the ancient Hebrew of having a son is at once the basis for a stable family and also accounts for the occasional polygamy, the custom of the levirate, divorce of the barren wife, and penalties meted on an adulterous wife. The author argues that this accounts also for the double standard, but a husband's infidelity is hardly justified by the fact that it does not call into question the parentage of his children.

The Hebrew family, as part of a culture dominated by religion, was a religious institution. Marriage, its foundation, was therefore sacred. So was the sexual union of husband and wife; and it was treated openly as befits something clean. It is our loss, Mace believes, that the Christian tradition often casts a shadow upon the sex life of married people. The rebellion against the family in our society is in part a rebellion against repression, repression that represents "non-Christian and sub-Christian accretions" to the basic institutions bequeathed by the Hebrews to Christianity.

The anthropology is generally excellent; only his chapter denying an earlier matriarchy in Hebrew history (an idea long since abandoned by serious anthropologists) strikes an amateurish note. This is a minor point and leaves a very high score. The argument on the whole is sound and the writing tight. It is the more surprising therefore that Mace appears to assume that European culture descends mainly from Hebraic, and any divergence is somehow a misconstruction of the single heritage. At the end he calls upon "all who value our Christian culture and tradition" to proclaim "the true Christian values," consisting of the Hebrew emphasis on the family (rather than the individual) as the basis of society. Are the Greek, Roman, Germanic, and other backgrounds of European culture only minor interruptions and "sub-Christian accretions" to be proclaimed away as errors in theological scholarship? Perhaps Professor Mace can view as "not essentially Christian" anything foreign to "the society within which Christianity had its birth," but this is a conception of Christianity as an isolated thread unravelled from the whole fabric. The Hebrew religion and family alike supported one another in a traditional Hebrew culture. Would the author's family which is "Christian" but not European be any stronger than one which is European but not Christian?

SOL TAX

Department of Anthropology
The University of Chicago

The Mammals of Minnesota. Harvey L. Gunderson and James R. Beer. Minneapolis: University of Minnesota Press, 1953. xii+190 pp. \$3.50.

THIS book is in part a revision of out-of-print earlier works on Minnesota mammals, although it incorporates much that is new. It consists largely of a systematic catalog, along with two shorter sections, one of which introduces the study of mammals and the other describes the geography of the state.

The authors' objective of "an accurate popular presentation for use by schools and others interested in mammals" is in general well attained, for that is exactly what the treatment suggests. The advanced student or the specialist in a particular mammalian group may find the brief accounts of species unrewarding. I think that the latter are really overly brief, at least for the mammals that especially interest the public as oddities, pests, game, or fur-bearers. But, for a high school or an elementary college textbook, this should be highly suitable. Not only may the beginning student learn about mammals as a science but he may also acquire a sound concept of the bearing of ecology upon the distribution and variety of mammalian life in a locality. And, by means of the useful keys, he should seldom need to identify a given specimen merely as "mouse," "bat," "gopher," and so forth, if he wishes to find out what it is.

PAUL L. ERRINGTON

Agricultural Experiment Station
Iowa State College

LETTERS

ADDENDA TO THE INTRODUCTION AND NOTES OF THE DIARY OF WILLIAM FELLOWES MORGAN

"The Diary of William Fellowes Morgan," which I edited, was published in *THE SCIENTIFIC MONTHLY*, September, 1953. This diary gives a detailed account of the latter part of a scientific expedition of Lewis Henry Morgan (L.H.M.), accompanied by his great-nephew, William Fellowes Morgan (W.F.M.), and others, followed by a description of the 1878 AAAS meeting in St. Louis.

A short time after this appeared, Professor Leslie A. White of the University of Michigan, wrote me that he had published the journal of L.H.M., kept during that same expedition. Later he sent me a reprint entitled, "Lewis H. Morgan's Journal of a Trip to Southwestern Colorado and New Mexico, June 21 to August 7, 1878." This journal was edited by Leslie A. White and published in *American Antiquity*, Vol. 8 (1942), pp. 1-26.

The journal of L.H.M. and the diary of W.F.M. supplement each other remarkably well. L.H.M. begins with the start from Cañon City on June 21. His journal, as a description of the trip, really ends on August 4, the day before their arrival in Conejos. His only other entry, dated August 7, is a very brief description of the pueblos and customs of the Taos Indians. The diary of W.F.M. begins with their arrival at Conejos on August 5. The only overlapping part of the two accounts, therefore, is the description of Taos, and even here many of the particulars are different.

The following portion of the first entry in L.H.M.'s published journal gives the reason for the trip and identifies the members of the party.

Cañon City, June 21, 1878

I did not intend to keep a journal, but bought this book to use in case we got as far as Taos, New Mexico. One reason is that it has become so difficult for me to write a legible hand. But I will commence at least and show why I am here. My nephew, David P. Morgan, of New York, asked me to go to Colorado with his two oldest sons, W. Fellowes [Morgan], now a junior at Columbia College, and David Percy [Morgan], now about sixteen, to which I consented. William S. Sloan and Donald B. Toucey were added to the party. We reached here the 19th of June, Fellowes and myself spending last Sunday at Highland, Ill., with Mr. Bandelier very pleasantly, while the rest of the party remained at the Lindell House, St. Louis.

In a footnote, White states that William S. Sloan and Donald B. Toucey were also students at Columbia. The latter is the "Donald" mentioned often in the W.F.M. diary. Evidently Sloan left the party before August 5. At Alamosa on August 12, W.F.M. wrote: "In the evening we met Judge Ira B. Felton who told us how

he had met Will Sloan and had loaned him some money."

W.F.M. stated that "Henry" left them on August 6. This was Henry Waller, the driver, who had taken the party in his wagon over the entire trip from Cañon City to Conejos, except for some of the side trips to ruins in rough country which had to be made on horseback. For example, L.H.M. states that General Heffernan gave them a letter of introduction to John Gregor who took them on horseback to the cliff house on the Mancos River which was described by W.F.M. in his AAAS paper. Back in Cañon City on August 14, Henry "appeared" and went with the three boys to Marble Cave.

The complete itinerary is given on a map drawn by White. Some of the routes, however, had to be marked "conjectural" (including the one from Conejos to Taos and back), because L.H.M. either described only the places visited or gave ephemeral landmarks. From Cañon City, the party traveled via South Park to Leadville, thence south to Saguache and west through Silverton to various places in Southwest Colorado; to Aztec, New Mexico, and back to Animas City, thence east through Pagosa Springs to Conejos, thence to Taos, New Mexico, and back to Conejos.

Since L.H.M. stated at the beginning of his journal that he had bought a note book chiefly to use at Taos, it is strange that he wrote so little about it and nothing concerning the journey there and back. Evidently he considered Taos of paramount importance, but his description of it is much shorter than most of those of other places he visited. It is also strange that W.F.M. wrote such a detailed description of the expedition from Conejos on, but, so far as we know, nothing at all concerning it during the first six weeks. After all, the remarkable dovetailing of the two accounts may not have been merely accidental. Since it was difficult in the beginning for L.H.M. to write, it may have been that, tired by the long trip, especially arduous for one of his age and infirmities, he did not feel able to continue his own journal. This may have been the reason that his nephew kept a record of the remainder of the trip. It is, therefore, possible that the two accounts supplement each other because they were intended to do so.

I am sorry that I did not know about the published journal of L.H.M. before the diary of W.F.M. appeared. This letter is now offered as additional material on "The Diary of William Fellowes Morgan."

TEMPLE R. HOLLCROFT

Wells College
Aurora, New York

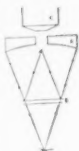
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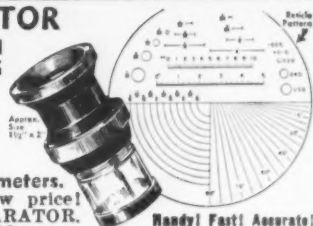
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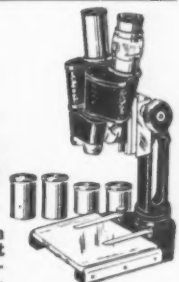
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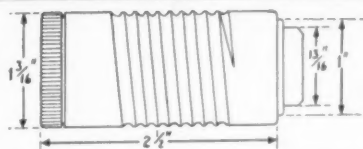
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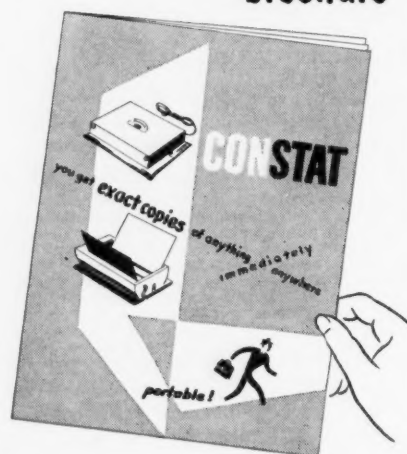
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New Books Received

- Planning Guide for Radiologic Installations.* Committee on Planning of Radiologic Installations of the Commission on Public Relations of the American College of Radiology, Wendell G. Scott, Chairman. Chicago, Ill.: Year Book Pub., 1953. xvi + 336 pp. Illus. \$8.00.
- Space Travel.* Kenneth W. Gatland and Anthony M. Kunesch. New York: Philosophical Library, 1953. x + 205 pp. Illus. + plates. \$4.75.
- Geography in the Twentieth Century.* 2nd ed. rev. Griffith Taylor, Ed. New York: Philosophical Library; London: Methuen, 1953. xi + 661 pp. Illus. + plates + maps. \$8.75.
- Simultaneous Linear Equations and the Determination of Eigenvalues.* National Bureau of Standards Applied Mathematics Series 29, 1953. L. J. Paige and Olga Taussky, Eds. Distrib.: Supt. of Documents, U. S. Govt. Printing Office, Washington 25, D. C. iv + 126 pp. \$1.50.
- Conversation with the Earth.* Hans Cloos. Trans. of *Gesprach mit der Erde* by E. B. Garside; ed. by Ernst Cloos and Curt Dietz. New York: Knopf, 1953. 409 pp. Illus. + plates + index. \$5.75.
- Die Botanische Buchillustration.* Ihre geschichte und bibliographie. Claus Nissen. Stuttgart: Hiersemann Verlags, 1951. vii + 324 pp. DM 120.00.
- Hypnotism.* An Objective Study in Suggestibility. André M. Weitzenhoffer. New York: Wiley; London: Chapman & Hall, 1953. xvi + 380 pp. \$6.00.
- Introduction to the Theory of Error.* Yardley Bers. Cambridge, Mass.: Addison-Wesley, 1953. vi + 65 pp. \$1.25.
- The Achievement Motive.* David C. McClelland et al. New York: Appleton-Century-Crofts, 1953. xxii + 384 pp. Illus. + plate. \$6.00.
- Biochemistry and Physiology of Nutrition*, Vol. II. Geoffrey H. Bourne and George W. Kidder, Eds. New York: Academic Press, 1953. xi + 641 pp. Illus. \$15.00.
- General Virology.* S. E. Luria. New York: Wiley; London: Chapman & Hall, 1953. xiii + 427 pp. Illus. \$8.50.
- Keeping and Breeding Aquarium Fishes.* C. W. Emmens. New York: Academic Press, 1953. x + 202 pp. Illus. \$4.50.
- The Major Features of Evolution.* George Gaylord Simpson. New York: Columbia Univ. Press, 1953. xx + 434 pp. Illus. \$7.50.
- Mathematics in Western Culture.* Morris Kline. New York: Oxford Univ. Press, 1953. xii + 484 pp. Illus. + plates. \$7.50.
- Methods of Theoretical Physics*, Parts I & II. Philip M. Morse and Herman Feshbach. New York: McGraw-Hill, 1953. xxx + 1978 pp. Illus. \$30.00. (\$15.00 each.)
- New World of the Mind.* Joseph Banks Rhine. New York: William Sloane, 1953. xi + 339 pp. \$3.75.
- Astronomical Photoelectric Photometry.* Symposium presented on December 31, 1951, at the Philadelphia meeting of the AAAS. Frank Bradshaw Wood, Ed. Washington, D. C.: American Association for the Advancement of Science, 1953. vii + 141 pp. Illus. \$3.75.
- Upper Paleozoic of Peru.* The Geological Society of American Memoir 58. N. D. Newell, J. Chronic, and T. G. Roberts. New York: Geological Society of America, 1953. vii + 276 pp. Illus. + plates.

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❧ Meetings ❧

February

- 15-18. American Inst. of Mining and Metallurgical Engineers, New York City. (E. H. Robie, 120 E. 41 St., New York 17.)
- 15-18. Soc. of Economic Geologists, New York City. (O. N. Rove, U.S. Geological Survey, Washington 25, D.C.)
- 15-20. Latin American Cong. of Physical Medicine, Medellin, Colombia. (C. L. de Victoria, 176 E. 71 St., New York 21, N. Y.)
- 19-25. International Management Cong., 10th, São Paulo, Brazil. (P. S. M. Phillips, Management House, Hill St., London W. 1, Eng.)
- 20-21. American College of Apothecaries, Chicago, Ill. (R. E. Abrams, 2173 Knorr St., Philadelphia, Pa.)
- 21-25. Latin American Cong. of Oto-Rhino-Laryngology, 3rd, Caracas, Venezuela. (V. Marquez Reverson, Centro Medico, Caracas.)
- 25-27. American Acad. of Forensic Sciences, Chicago, Ill. (R. Turner, Dept. of Police Administration, Michigan State College, East Lansing.)
- 26-27. American Physical Society, Austin, Tex. (K. K. Darrow, Columbia Univ., New York 27.)
- 28-4. Pan American Assoc. of Oto-Rhino-Laryngology and Broncho-Esophagology, Mexico City, Mex. (C. L. Jackson, 1901 Walnut St., Philadelphia 3, Pa.)

March

- 4-5. American Soc. for Metals, mid-winter, Boston, Mass. (W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.)
- 6. Symposium on Air Pollution and its Control, 2nd annual, Staten Island, N.Y. (N. Colosi, Wagner College, Staten Island, N.Y.)
- 8-9. National Symposium of Division of Organic Chemistry, Chemical Inst. of Canada, Montreal, Canada. (G. E. McCasland, Dept. of Chemistry, Univ. of Toronto, Toronto, Ont.)
- 8-10. American Inst. of Chemical Engineers, Washington, D.C. (S. L. Tyler, 120 E. 41 St., New York 17.)
- 8-10. The Wildlife Soc., annual, Chicago, Ill. (G. A. Petrides, Dept. of Fisheries and Wildlife, Michigan State College, East Lansing.)
- 9-12. American Mosquito Control Assoc., annual, Atlantic City, N.J. (R. E. Dorer, 301 Essex Bldg., Bank & Plume Sts., Norfolk, Va.)
- 11-13. American Orthopsychiatric Assoc., New York, N.Y. (M. F. Langer, 1790 Broadway, New York 19.)
- 11-13. Kappa Delta Pi, Lafayette, Ind. (E. I. F. Williams, 277 E. Perry St., Tiffin, Ohio.)
- 11-13. National Wildlife Federation, annual, Chicago, Ill. (L. F. Wood, 232 Carroll St., NW, Takoma Park 12, D.C.)
- 15-19. National Assoc. of Corrosion Engineers, annual, Kansas City, Mo. (A. B. Campbell, 1061 M & M Bldg., Houston 2, Tex.)
- 16-17. Symposium on Monte Carlo Methods, Gainesville, Fla. (H. A. Meyer, Univ. of Florida, Gainesville.)
- 18. Inst. of Mathematical Statistics, Eastern regional, Gainesville, Fla. (H. A. Meyer, Univ. of Florida, Gainesville.)
- 18-20. American Physical Soc., Detroit and Ann Arbor, Mich. (K. K. Darrow, Columbia Univ., New York 27.)
- 20. The Biochemical Soc., annual, London, Eng. (F. L.

Warren, Biochemistry Dept., London Hospital Medical College, London W. 1.)

- 21. International Assoc. for Dental Research, French Lick, Ind. (E. H. Hatton, 311 E. Chicago Ave., Chicago 11, Ill.)
- 22-24. American Assoc. of Dental Schools, annual, French Lick Springs, Ind. (M. W. McCrea, 42 S. Greene St., Baltimore, Md.)
- 22-25. Inst. of Radio Engineers, annual, New York City. (E. K. Gannett, 1 E. 79 St., New York.)
- 24-1. American Chemical Soc., 125th national, Kansas City, Mo. (R. M. Warren, 1155 16 St., NW, Washington, D.C.)
- 25-27. Optical Soc. of America, spring, New York City. (A. C. Hardy, Massachusetts Institute of Technology, Cambridge 39.)
- 25-27. Symposium on the Origins of Resistance to Drugs, Washington, D.C. (M. G. Sevag, Dept. of Microbiology, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)
- 26-28. American Assoc. of Physical Anthropologists, annual, Yellow Springs, Ohio. (J. L. Angel, Jefferson Medical College, 307 S. 11 St., Philadelphia 7, Pa.)

April

- 1-3. National Science Teachers Assoc., annual, Chicago, Ill. (R. H. Carleton, 1201 16 St., NW, Washington 6, D. C.)
- 2-3. American Assoc. of University Professors, Buffalo, N. Y. (R. E. Himstead, 1785 Massachusetts Ave., NW, Washington 6, D. C.)
- 3-10. Pan American Cong. of Veterinary Medicine, 2nd, São Paulo, Brazil. (J. S. Veiga, Rua Pires da Mota 159, São Paulo.)
- 5-8. Symposium on Orthopteran Acoustics, Jouy-en-Josas, France. (Laboratoire de Physiologie Acoustique, Institut National de la Recherche Agronomique, Jouy-en-Josas.)
- 5-10. International Sound-Recording Conf., Paris, France. (Société des Radio-electriciens, 10-14 Avenue Pierre-Larousse, Malakoff, France.)
- 5-11. Pan American Cong. on Agronomy, 2nd, São Paulo, Brazil. (J. Moraes, Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba, Brazil.)
- 6-9. Conf. on the Physics of Particle Size Analysis, Nottingham, Eng. (Inst. of Physics, 47 Belgrave Square, London S.W. 1.)
- 7-9. American Assoc. of Anatomists, Galveston, Tex. (N. L. Hoerr, Western Reserve Univ. School of Medicine, 2109 Adelbert Rd., Cleveland 6, Ohio.)
- 7-10. Conf. on Luminiscence, Cambridge, Eng. (S. T. Henderson, 47 Belgrave Square, London, S.W. 1.)
- 8-9. European Assoc. against Poliomyelitis, Paris, France. (Secretariat General, 130 Rue de Linthout, Brussels, Belgium.)
- 9-10. Eastern Psychological Assoc., annual, New York, N. Y. (Gorham Lane, Dept. of Psychology, Univ. of Delaware, Newark.)
- 10-11. American Acad. of Optometry, western regional, Berkeley, Calif. (D. B. Carter, School of Optometry, Univ. of California, Berkeley.)
- 11-15. American Physiological Soc., Atlantic City, N. J. (M. O. Lee, 2101 Constitution Ave., Washington 25, D. C.)